The dead heart of Australia

John Walter Gregory

THE DEAD HEART
OF AUSTRALIA

THE CAMEL TRAIN CROSSING THE STONY DESERT NEAR WUNTANOORINNA.

THE DEAD HEART OF AUSTRALIA

A JOURNEY AROUND LAKE EYRE
IN THE SUMMER OF 1901-1902,
WITH SOME ACCOUNT OF THE
LAKE EYRE BASIN AND
THE FLOWING WELLS
OF CENTRAL AUSTRALIA

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WITH MAPS AND ILLUSTRATIONS

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TO THE

GEOLOGISTS OF AUSTRALIA,

AS A SLIGHT TRIBUTE OF RESPECT

FOR THE MAGNIFICENT COURAGE, ORIGINALITY

AND INSIGHT

WITH WHICH THEY HAVE DISCOVERED

THE INTERESTING GEOLOGICAL HISTORY OF

AUSTRALIA

PREFACE

THE expedition, of which some of the results are stated in this volume, was undertaken in the hope that it would be the first of a series, for the study of the interior of South-eastern Australia, conducted in connection with the geological school of Melbourne University. The narrative is largely reprinted from some letters to the *Melbourne Age*. It is repeated in the hope that it may be of value, as giving some idea of the conditions of the Lake Eyre district, in an interesting stage in its development. On the return of the expedition, I had at once to take up the duties of Director of the Geological Survey Branch of the Mines Department of Victoria, and had therefore to postpone work on the considerable geological collections we had made. Most of the book was completed three years ago; but its publication was delayed in the hope that I might find time to finish an account of the geology of the Lake Eyre district.

In excuse for the fewness of the references in the chapter on the aborigines, I may explain that I have given them more fully in another work,

which I had hoped would have been published at the same time.

The last chapter was written for the *Melbourne Argus*; it is reprinted, with a few verbal alterations, as I have had so many applications for the date of its publication and for a copy of the article. Several correspondents have written to me about the estimated cost of excavation of such a canal: the estimate quoted is that of the Secretary for Public Works in South Australia. I did not make any independent estimate; for none seemed to be possible without undue trouble, as operations on so vast a scale could not be conducted at ordinary prices.

Owing to the kindness of the Secretary of Broken Hill Water Supply, Limited, I have recently received the figures of the estimated evaporated from its reservoir; and the following figures may be quoted from their bearing on the evaporation rates considered in Part III.

Year.	Aver. max. depth of water.	Fall of water in inches.		
		Total.	Due to pumping.	Due to evaporation.
1893	16 ft. $8\frac{1}{4}$ in.	$96\frac{1}{8}$	7·49	88·58
1894	13 ft. $1\frac{5}{8}$ in.	$102\frac{5}{8}$	18·03	84·59
1895	15 ft. $7\frac{3}{4}$ in.	$103\frac{5}{8}$	20·72	82·90
1896	20 ft.	$100\frac{7}{8}$	14·54	86·46

I have to express my best thanks to my companions, Messrs. H. J. Grayson, A. J. Donaldson, E. B. Dow, C. M. Lyons, P. Guy Smith, and F. Voss Smith, for their splendid help throughout

the journey. To my assistant, Mr. Grayson, on whom much of the hard work of the expedition fell, I am especially indebted; and to him are due the photographs opposite pages 34 (lower figure), 44, 60, 76, 110, 116, 142, 164, and 178 The upper photograph opposite page 34 was taken by Mr. G. P. Smith. That of the corroboree opposite page 210, I owe to the Rev. O. Siebert; for as the corroborees are performed at night, it is only possible to photograph them at "matinees" arranged for the purpose.

I am much indebted to T. A Coghlan, Esq., I.S.O., Agent-General for New South Wales, Sir Horace Tozer, K.C.M.G., Agent-General for Queensland, and Hon. J. G. Jenkins, Agent-General for South Australia, for kindly lending me copies of some official literature, with which to bring up the statistics of water supply more up to date. And owing to the distance from a good library of Colonial literature, I am quite aware that the Bibliography of Lake Eyre is incomplete. Finally, I have to renew my thanks for the kind help and hospitality received from the Government and people of South Australia; and amongst the many whose names occur to me, I have especially to thank Messrs. T. Gill, J. W. Jones, and W. Howchin.

GLASGOW,
March, 1906.

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PART I

INTRODUCTION

CHAPTER I

HOW THE KADIMAKARA CAME DOWN FROM THE SKIES

Sky created us; but we shall be consumed by Earth.

A proverb of the Giriama, a tribe in British East Africa, near Mombasa.

It is strange to find fables similar to those of the more northern nations even in the heart of Africa. Can they be the vestiges of traditions of animals which no longer exist? The fossil bones which lie in the calcareous tufa of this region will yet, we hope, reveal the ancient fauna. LIVINGSTONE.

ACCORDING to the traditions of some Australian aborigines, the deserts of Central Australia were once fertile, well-watered plains. Instead of the present brazen sky, the heavens were covered by a vault of clouds, so dense that it appeared solid; where to-day the only vegetation is a thin scrub, there were once giant gum-trees, which formed pillars to support the sky; the air, now laden with blinding, salt-coated dust, was washed by soft, cooling rains, and the present deserts around Lake Eyre were one continuous garden.

The rich soil of the country, watered by abundant rain, supported a luxuriant vegetation, which spread from the lake-shores and the river-banks far out across the plains. The trunks of lofty gum-trees rose through the dense undergrowth, and

upheld a canopy of vegetation, that protected the country beneath from the direct rays of the sun. In this roof of vegetation dwelt the strange monsters known as the "Kadimakara" or "Kadimerkera."

Now and again the scent of the succulent herbage rose to the roof-land, and tempted its inhabitants to climb down the gum-trees to the pastures below. Once, while many Kadimakara were revelling in the rich foods of the lower world, their retreat was cut off by the destruction of the three gum-trees, which were the pillars of the sky. They were thus obliged to roam on earth, and wallow in the marshes of Lake Eyre, till they died, and to this day their bones lie where they fell. After the destruction of the gum-trees, the small holes in the forest-roof increased in number and size, until they touched one another, and all the sky became one continuous hole; wherefore the sky is called "Puri Wilpanina," which means the "Great Hole."

At times when the country is wasted by prolonged drought, or the floods from the Queensland hills lie too long upon the hunting-grounds, the aborigines make pilgrimage to the bones of the Kadimakara. There corroborees are held, at which blood sacrifices are offered and dances performed to appease the spirits of the dead Kadimakara, and persuade them to intercede with those who still dwell in the sky, and control the clouds and rain.

This legend is part of the folk-lore of the Dieri, a tribe found in the country along Cooper's Creek, eastward from Lake Eyre. The same legend is told by other tribes in the same district of Central Australia, with variations in the form of the names, and in other details. It may have arisen as a pure fiction, invented by some imaginative, story-telling native, to explain why large bones are scattered over the bed of Cooper's Creek. It may, on the other hand, be a shadowy reminiscence of the geographical conditions which existed in some distant ancestral home of the aborigines, or of those which prevailed in Central Australia, at some remote period.

What geographical conditions, it may be asked, could have given rise to such a legend?

To the dweller in the open down or moorland, the idea that the vault of heaven could be upheld by trees, or that the open, transparent sky could support heavy animals of flesh and bone, seems the idlest fancy. But to the man who knows the tropical forest, it appears inevitable that the first attempts by primitive forest-people to explain the world around them, must closely follow the lines of the Kadimakara legend.

If the pygmies in the East African forests have any theory of the limited universe known to them, they probably regard it as a two-storied structure, in which they occupy the lower floor. They live in a jungle of bamboos and dense undergrowth, while high above them is a thick, felted layer of

foliage and creepers, upheld by the trunks of lofty junipers, which rise straight to a great height before they branch. The tangled layer of vegetation overhead deprives the natives of any knowledge of the world above their tree-tops. They are covered by a sheet as opaque and as continuous as a roof slightly out of repair. In that roof live monkeys and birds and beasts, that never descend to the ground below; while the animals that live and move and have their being in the undergrowth are equally cut off from the world above. The primitive hunter has some slight knowledge of the jungle-roof above him. He hears the harsh halloa of the colobus, the shrill cry of birds when they fall a prey to snakes or monkeys; his keen eye can detect the prized fur of the colobus, despite its close resemblance to the long, hanging masses of grey-beard lichen, that drape the black branches of the trees. But the dweller in the underlying jungle knows nothing of the region above the tree-tops. In the dry season, when the forest is not covered in mist, he may see the stars slowly crossing the holes in the roof; but he knows nothing of their distance, and probably thinks of them only as fire-flies, with an unusually slow and steady flight. The roof above him is his highest heaven, which supplies the rain that drips heavily from the sodden foliage. The occasional fall of a dead bird or a monkey is to him as much a gift from the gods as were the sky-stones, that supplied the Siberians and Eskimo with iron. The change from the dark of

night to the dull gloom, that pervades the lower forest at midday, is clearly due to some change in or above the roof. But the forest-dweller has no clue to the distance; so he flattens the whole universe above him into one solid floor, supported by the tree-trunks, just as the Greeks projected all the star-zones into one solid firmament.

Those who interpret the Kadimakara legend by the light of a knowledge of tropical forests, naturally see in it either a reminiscence of the time, when the geographical conditions of Central Australia were different from those that prevail at present, or a reminiscence of the country whence the aborigines migrated to Australia. If, therefore, the geologist can determine whether the bones of the extinct monsters of Lake Eyre correspond to those described in the aboriginal traditions, he can throw light on several interesting problems. If the legends attribute to the extinct animals characters which they possessed, but which the natives could not have inferred from the bones, then the legends are of local origin. They would prove that man inhabited Central Australia, at the same time as the mighty diprotodon and the extinct, giant kangaroos. If, on the other hand, there is no such correspondence between the legends and the fossils, then we must regard the traditions as due to the habit of migratory peoples, of localising in new homes the incidents recorded in their folk-lore.

The geologist may, therefore, hope to help the student of the Australian aborigines, by explaining

some of their traditions, by throwing light on their migrations, and by showing the date of their arrival in Australia.

At the suggestion of Dr. A. W. Howitt, the chief authority on the Lake Eyre natives, I arranged to visit Lake Eyre, in the hope of making a collection of its fossil bones and studying the problems of its geology. Undismayed by thermometer records, my assistant, Mr. H. J. Grayson, and several of my students agreed to share the discomforts of Central Australia in midsummer. The expedition was not described to them as likely to prove a comfortable picnic, for the Lake Eyre basin was represented to me as the hottest and dustiest district in Australia. The Rev. Otto Siebert, of the Kilalpaninna Mission, wrote to warn us that, at the time we proposed to visit him, the temperature in the previous year had been from 118 to 125 degrees in the shade. Members of even the middle generation of Australian explorers, such as Warburton, had scouted the possibility of travel through the Lake Eyre basin in midsummer. I pointed out, in reply, that Lewis had marched round the northern end of the lake in the summer of 1874-5; but he and his party had nearly perished in a sandstorm,[1] and friends in Adelaide kindly warned me not to forget that Lewis had travelled in a good year, while the country now lay devastated by the longest and

[1] J. W. Lewis's Journal of Lake Eyre Expedition, 1874-5 (Parl. Pap., South Australia, 1875, No. 19, p. 10).

most disastrous drought in Australian annals. But nothing could daunt the enthusiasm of my companions; and it was arranged that we should start as soon as our December examinations were over.[1]

I went to Adelaide a day ahead of the rest of the party to finish our arrangements and to profit by the words of wisdom of some of its citizens, who best know the Lake Eyre country. I received most valuable help and advice from many

[1] The following letter from one old explorer appeared in the *South Australia Register* (December 17, 1901):

"I notice that Professor Gregory is taking a trip to Lake Eyre with several students from the Melbourne University 'to investigate certain "legendary" animals, and to pay particular attention to fossil bones which are said to exist in the Lake Eyre basin,' and each student will have to pay particular attention to one branch of geology. I have heard of scientific men being martyrs to science where there was no help for it. Through their bravery the world has been rendered richer; and I, as a humble observer, can only record my small amount of praise. But it is suggested to my mind that the visit to a place like Lake Eyre on camels by young students, who have only just completed their course, at this time of the year is little short of madness. It is profoundly to be hoped that while digging for fossils they won't unwittingly be digging their own graves. As a play on words, they may have been students, but their experiences will now be that under a broiling sun they will be stewed. Why, sir, my experience is that in that country the heat at this time of year is enough to make a crowbar sweat, and on a crosscut saw, exposed for a short time, one could cook a chop with the greatest ease. I am delighted at any scientific investigation, and shall be glad to know that this continent is, what it a long time ago was asserted to be, one of the oldest in the known world. Still, to secure this knowledge there is no need to rush heedlessly at the point of self-destruction. It is easy to remember what some hardy explorers and thoroughly hardened bushmen underwent forty or fifty years ago; and the climatic conditions have not changed much. I only hope the party will return safely, but still think the undertaking hazardous, and am convinced that everything could as well have been done in cool weather, rather than under the intense heat, which at this season of the year can but be expected."

friends in Adelaide. Mr. Gill, the Under-Treasurer, helped me by his wide acquaintance with the literature of South Australian exploration; Mr. H. Y. L. Browne, the Government Geologist, gave me the benefit of his unrivalled knowledge of the geology and geography of Central Australia; Mr. J. W. Jones told me the latest information about the artesian wells, which, under his superintendence, have done so much to keep open the stock route to western Queensland, across the eastern part of the Lake Eyre basin; Dr. E. C. Stirling, F.R.S., Curator of the South Australian Museum, showed us its rich store of fossil bones of huge birds and animals, that had given world-wide fame to Lake Callabonna, the south-eastern member of the long chain of lakes to which Lake Eyre belongs; Mr. Howchin, of the University, showed me the no less important specimens, which prove that glaciers flowed down the South Australian hills in one of the earliest periods known to geologists (the Cambrian); the late Charles Winnecke, the leader of the Horn Expedition, explained the arrangements he had kindly made for us, as to the engagement of camels and men.

On Friday, December 13, 1901, we started from Adelaide by the early morning train. Notwithstanding the hour, several of our friends came to bid us good-speed and give us their last advice and their last additional information. My companions on the journey were Mr. H. J. Grayson, assistant in the Geological Department of the Melbourne

University, and Messrs. A. J. Donaldson, E. B. Dow, C. M. Lyons, P. Guy Smith, and F. Voss Smith, "University students all." Laycock, known to readers of Professor Spencer's narrative of the Horn Expedition, came with us as cook. Our camels, with the camel-driver, Steer, were to meet us at Hergott Springs, some four hundred and forty miles north from Adelaide.

The railway journey to Hergott takes two days. For most of the way the gauge of the line is narrow, and as, owing to the great diurnal variation of temperature in this country, the rails cannot be closely laid, the speed of the trains is necessarily slow. North of Quorn, the train goes only every other day; from Hergott to Coward's Springs there is one train a week; and on the last section of the line there is but one train a fortnight.

As we approached the end of our railway journey the heat became more intense, and we received the lugubrious sympathy of residents along the line, who came down to meet the occasional train. Some of them obviously regarded us as either ignorant of the fact that summer in the southern hemisphere occurs at Christmas, or else as not in our right minds. My apology that we were visiting the country at that time of year because it was the only time available to us was dismissed as so miserably inadequate, that I never dared to repeat it. The assertions made to us as to the fatal fury of the heat, the delicacy of the fragile

camel, and the appalling scarcity of water, as well as the warnings to beware of the fate of some early explorers in the Lake Eyre basin, suggested a fresh explanation of the Kadimakara legend. Might it not be an allegory on the experiences of Sturt and the tragic fate of Burke and Wills?

When settlements were first founded in South Australia, men cherished the hope that beyond the waterless wastes, that lay behind the coast-lands, rose a cooler, better land, with well-watered valleys, timbered hills, and turfed steppes. The Great Valley of South Australia and the plains of the Darling River offered to serve as paths, by which the inhabitants of the coast-lands could cross the desert zone to the land of promise beyond. Sturt went north along the Darling route, and at first made easy progress; but then the cool season ended, the rains ceased, the pools dried up, and the burning summer sun cut off his retreat as effectually as the destruction of the gum-trees stopped the retreat of the Kadimakara. Camped beside a water-hole, Sturt and most of his men managed to survive the summer, though they endured agonies from the torturing heat. His descriptions of his sufferings were so vivid that, when they reached Adelaide, they turned his wife's hair white in a single night.[1]

According to Sturt's observations, the *mean* shade temperatures for December, January, and February were 101, 104, and 101 degrees respect-

[1] N. G. Sturt, *The Life of Charles Sturt* (1899), p. 257.

ively. Under this heat, says Sturt,[1] "every screw in our boxes had been drawn, and the horn handles of our instruments, as well as our combs, were split into fine laminæ. The lead dropped out of our pencils; our signal-rockets were entirely spoiled; our hair, as well as the wool on the sheep, ceased to grow; our nails had become as brittle as glass. The flour had lost more than 8 per cent. of its original weight, and the other provisions in a still greater proportion. The bran in which our bacon had been packed was perfectly saturated, and weighed almost as heavy as the meat. We were obliged to bury our candles. A box of citric acid in Mr. Browne's box became fluid, and, escaping, burnt a quantity of his linen, and we found it difficult to write or draw, so rapidly did the fluid dry on our pens and brushes."

In spite of their sufferings, Sturt and most of his party escaped the fate of the Kadimakara. Burke and Wills were less fortunate. They also reached the Lake Eyre basin in quest of better lands beyond the desert. They were cut off from the south by the summer, and eked out a miserable existence until death relieved their sufferings. Undeterred by their fate, men have never been found wanting to continue the work, until now a well-equipped and admirably managed railway runs far out into the desert-land. Lake Eyre is surveyed, most of the water-holes are known,

[1] C. Sturt, *Narrative of an Expedition into Central Australia during 1844-6* (1849), vol. i., pp. 305-6.

and the tracks are clearly marked on the excellent maps of the South Australian Lands Department. Hence men can now safely traverse districts, over which the pioneers found their way with danger and pain.

We had left the cool and fertile lands of Victoria for a less substantial object than that which tempted the Kadimakara to their fate. We had, however, the comfort of knowing that our gum-tree—the Great Northern Railway of South Australia—would be ready to bring us back, as safely and easily as it was taking us to the edge of the deserts we hoped to explore.

PART II

NARRATIVE

CHAPTER II

THROUGH THE GREAT VALLEY OF SOUTHERN AUSTRALIA

And I will give her the valley of Achor for a door of hope.
HOSEA ii. 15.

THE early settlers at Sydney had little inducement to wander inland. The coast-lands were fertile and attractive, and the way to the interior was barred by cliff-faced mountains that long proved insurmountable. The rivers offered no help, as they soon lost themselves in a maze of gorges or flowed in valleys parallel to the coast. At Adelaide, on the other hand, Nature offered every temptation to an advance inland. The lowlands around the city were bleak and arid, and exposed to the hot north wind, while the highlands behind were inconvenient of access, and their soil was thin and poor. The long strip of coast-plain offered a broad and easy path to the interior; the Mount Lofty Range, on the east, prevented travellers from straggling off the direct northern road; Spencer's Gulf, like a finger, pointed northward, and offered water carriage for the first two hundred miles of the way, to the very threshold of the unknown interior.

At Sydney, when we look over the city, the eye rests on the intricacies and mystery of its harbour, with its many bays and islands which we long to explore. The imagination is fed by them, and not until they have become completely familiar does our attention turn to the mountains and the interior.

Adelaide is a complete contrast in this respect. It lies in the middle of a level plain, five miles from the coast, which stretches away in a straight line on either hand. From the edge of the Mount Lofty Range the view is extensive and instructive. It includes the broad band of coastal plain; Adelaide, with its two spires and its many parks; the smoke and masts of the port; the suburban townships, each in its grove of pines; and in the distance is the glistening beach and the sparkling waters of St. Vincent's Gulf. There is little here to enchain the imagination. In spite of the many elements of beauty, the view, as a whole, is simple and unsatisfying; its features are all taken in at a glance; and the eye turns instinctively from the Adelaide plains, and follows along the gullied face of the hills until, far in the distance, all is lost in the soft northern haze.

The mysterious fascination of that northern view was felt by some of the earliest settlers at Adelaide. It allured them northward with the hope of finding an easy road to the interior, along what would certainly prove to be the shortest route across the continent. Gulfs usually occupy

the lower ends of great valleys, and Spencer's Gulf was found to lead northward to a depression, between the mountain uplands of the Gawler Range to the west, and the Flinders Mountains to the east. Between them is a level plain forming an open door to the interior, of which Mount Baxter and Mount Brown are the mighty gate-posts. Through that portal could be seen a level plain occupying the floor of a low valley.

This discovery showed that Spencer's Gulf is part of a great north and south depression, which we may call the Great Valley of South Australia. Within three years of the foundation of Adelaide its enterprising citizens had begun the exploration of this valley by the two expeditions of E. J. Eyre, subsequently the Governor of Jamaica. The results of Eyre's journeys were economically disappointing. He found that this promising route to the interior was a snare. The expected valley was there; its grade was easy; the country on its floor was open; but instead of fertile plains and a river commensurate in size with the vast area it was supposed to drain, he found only deserts, and brine springs, and the belt of salt swamps which he called Lake Torrens.

Need for water drove Eyre from the valley to the hills; he kept along them to the north, and he reached two mountains, which he named Mount Deception and Mount Hopeless. From them he saw what he thought was a continuation of Lake Torrens, running eastward, and then

bending southward so as to cut him off from the interior. The hilly country, he concluded, was a peninsula, within the arms of a lake shaped like a horse-shoe. "On every side," said Eyre, "we were hemmed in by a barrier which we could never hope to pass." Reluctantly he returned south, and started westward on what proved to be the most dramatic expedition in Australian annals.

The next serious attempt to go northward was made by Sturt, who followed the course of the Darling, and thus got farther to the north. He turned westward around the north of Eyre's horse-shoe lake, to find the continuation of the Great Valley. But he found himself in a desert of shifting sand-hills and plains covered with such a close pavement of stones that his horses left no footprints and his carts cut no wheel-ruts. He said that vegetation had no chance of existence in this "Stony Desert," and described the creek-beds as "white as snow," from their salt crust. Sturt, luckier than his successors Burke and Wills, escaped with his life from his "Stony Desert"; but his descriptions kept men from following his footsteps for nearly two decades.

On the western side of the Great Valley men were more fortunate; Babbage, Stuart, and Warburton worked their way northward, and found a long line of fresh-water springs. They proved that the valley of Lake Torrens had not a long steady ascent into the interior, but was divided

into distinct basins. North of Lake Torrens is a great depression, which is now known to sink below sea-level. The middle of this low depression is occupied by the 4,000 square miles of barren flats and salt swamps that form Lake Eyre.

The first point of interest in our journey was the nature and former extent of the Great Valley of South Australia. According to the well-known theory of Alfred Russel Wallace, Australia once consisted of two islands—one formed of the plateau of Western Australia, the other of the highlands of Eastern Australia. The strait that separated these islands was thought to have extended up the valley of the Murray to the Darling, and across the Lake Eyre basin to the Gulf of Carpentaria. According to this view, the Gulf of Carpentaria, the low-lying country south of it, the basin of Lake Eyre, the western part of the Murray valley, Lake Torrens, and Spencer's Gulf were all part of a great, and once continuous, trans-continental valley. This valley is now interrupted by two transverse ridges. The northern ridge forms the saddle between Hughenden and Cloncurry, and is the watershed between Lake Eyre and the Gulf of Carpentaria. The second is the mountain-range between Lake Eyre and Lake Torrens.

The existence of the supposed trans-continental valley is a question of primary importance in the

physical history of Australia ; and at first sight the evidence in its favour appears conclusive. That an inland sea once extended from the Gulf of Carpentaria as far south as the northern end of Lake Torrens is unquestionable; and from the southern shore of this former sea, Lake Torrens and Spencer's Gulf continue the depression across the rest of the continent to the southern coast.

Hence the former existence of a continuous trans-continental valley appeared to be definitely established, and to explain satisfactorily the relations of the great Lake Eyre basin. But the question is not so simple as, at first, it seems to be. It is doubtful whether the northern sea and the southern valley were in existence at the same time, and whether they ever actually communicated with one another. The basin of Lake Torrens was probably not formed until long after the sea had withdrawn from Lake Eyre to the Gulf of Carpentaria. So that it is not certain that Australia was ever completely divided by the supposed trans-continental valley.

Accordingly, the first question to be settled in the history of Lake Eyre is whether it is part of a trans-continental valley. If so, it should once have been joined to the Great Valley of South Australia, it should have been formed by the same series of movements, and should date from the same period in the earth's history. To solve this problem we require to know not only

the age of Lake Eyre, but also that of the basin of Lake Torrens. On the journey northward from Adelaide our attention was therefore eagerly turned to such study of the country as we could make from the railway train, guided by the maps and reports of Mr. H. Y. L. Browne.

The Great Northern Railway of South Australia does not follow the Great Valley throughout. It starts in this valley at Adelaide, and it runs forty miles along its floor in the Torrens basin ; but, like the explorers, the railway has been driven for most of the way from the valley to the hills, sending branch lines into the valley, to reach the coast at Port Pirie and Port Augusta. The railway crosses the Adelaide plain for over forty miles, to the Light River at Hamley Bridge. The Light and the adjacent rivers have cut for themselves such wide and deep valleys that their floors merge imperceptibly into that of the main valley. The bold scarp that here, as elsewhere, must have once bounded the Great Valley has been worn away, and even its exact site is apparently unrecognisable.

The railway follows the course of the Gilbert River until, after a steady rise of seven hundred feet in twenty-four miles, it passes out to the open, undulating downs on the plateau, which forms the eastern boundary of the Great Valley. This country is crossed by long, narrow, treeless ridges, which run north and south, separating alluvial plains, which at first appear like old lake-basins. But as we saw more of these plains, we learnt that they

are really due to the accumulation of waste material from the hills, which collects in the depressions more rapidly than the feeble streams can wash it away. We crossed a succession of these dry basins and bare ridges, our height varying from a thousand to two thousand feet above the sea.

In the afternoon the line turned eastward and crossed a gap through one of the meridional ridges into the basin of the Willochra River. This basin was of the same character, but was much larger than those we had seen to the south. It is fifty miles in length and from eight to sixteen miles in width. The whole plain was dry and waterless, but there were signs of heavy floods along the channel of the Willochra River; and the small but apparently prosperous townships showed that the district is rich agriculturally. The main geological interest of this basin is in the mountain-range, that serves both as its western boundary and as the eastern wall of the Great Valley.

As we crossed the basin we could see the main features of this range; in the south, the precipitous face of Mount Remarkable rises like a long, blue wall above the yellow plain; nearer to the west stands the rounded summit of Mount Brown (3,200 feet) and the rugged Devil's Peak, guarding the Pichi-Richi Pass, by which the railway crosses the mountains to Port Augusta.

The train stopped for the night at Quorn, at the foot of the pass, and to get a better idea of the mountain-range and its relations to

the Willochra basin, Voss Smith and I walked after dinner to the cemetery hill. We were rewarded by a panoramic view, illuminated by the pure bright colours of the afterglow. The western plains, rose-tinted by reflection from the clouds, led up to the jagged mountain-range, which stood black and sharp as a silhouette against a band of lurid yellow sky. This narrow belt of open sky was closed above by a bank of heavy clouds, their long, straight, lower edge aglow with pink, which faded upward into high domes of purple.

Next morning the train continued its journey over the Willochra basin, near the foot of the Ragless Range. The country was still apparently a rich, wheat-growing country, with a fertile loamy soil. We had a view of the broad pass, a mile in width, through which the Willochra River escapes westward to Lake Torrens; but our train carried us farther eastward into another flat-floored basin, with a lighter and poorer soil.

We passed the townships of Hawker and Hookina, and the train made a slight ascent to the summit of the Mernimerna Pass. Thence we descended rapidly, with many sharp curves, along a barren but picturesque valley, between the bold cliffs of the Elder Mountains to our north, and the Yappala Range to the south. This pass led down to an arid plain. At first it appeared to be another dry basin, for it was closed to the south by hills; but it is widely open to the north, and its western rim, Mount Eyre, slopes downward, and the flat-

floored valley, like an estuary, opens into the broad plains beside Lake Torrens.

We were now at a lower level, and in more barren country than we had been since leaving the Adelaide plains. The ground was sandy and littered with sand-polished pebbles; the vegetation consisted of tufts of dead grass, a few shrivelled herbs, and here and there a grey, dry shrub; the only trees were a few small gums along the waterless channel of a creek. The country was level, and the train ran for miles in a straight line parallel to the precipitous face of the Elder Range, from the foot of which the plain sloped gradually westward to Lake Torrens. We were disappointed in not actually seeing the lake; but we saw its mirage effects. We seemed to be looking across a broad river, a delusion heightened by the dark, whirling pillars of sand, which slowly travelled up the valley like the columns of smoke from steamers. The country looked hopeless from an agricultural point of view. But it was all fenced: so the soil is clearly better than it seems; and the name of one station—Meadows—unless given in derision, shows that the country does not always lie in the desert condition in which we saw it.

After giving us time for a hasty lunch at Parachilna, at the "Prairie Inn," to which we waded across the station-yard, ankle deep in sand, the train turned eastward and climbed up into the hilly country around Beltana. There we

finally left the Great Valley of South Australia, which was diverted to the west by a line of hills that run westward from the Elder Range, through Mount North-West and the Willouran Range. The train crossed the Beltana hills, and descending the northern slope, we passed over the small coal-field of Leigh's Creek and entered the basin of Lake Eyre. Then followed another marked change in the structure of the country. We ran out on to a wide sandy plain, broken by flat-topped hills, trending east and west and sloping downward to the north.

To the west we could see the old Willouran Range, its irregular outline standing up dark against the yellow glow of the twilight, and its blunt, rounded hummocks showing that they were hills, worn down to mere stumps by ages of denudation and decay. We watched them closely, and were half sorry to see them gradually fading from our view; for they were rocks of a type familiar to us in Victoria. We lost sight of them in the deepening gloom, as the train and its dust-cloud rushed across the sand-strewn plain. Soon the starlit sky hung low on every side of us, and the horizon was a long level line as at sea. The last of the old rocks and the familiar geographical features of the mountain girdle had been left behind us, and we were out on the vast desert plains of the central basin of Australia.

CHAPTER III

THE GATHERING AT HERGOTT SPRINGS

> The desert circle spreads,
> Like the round ocean, girdled with the sky.
>
> SOUTHEY.

FOUR hundred and forty miles from Adelaide the Northern Railway of South Australia turns suddenly westward to cross the hills between the foot of the Willouran Mountains and the southern shore of Lake Eyre. At the bend of the railway is the township of Hergott, which has grown up around a group of springs named, not by a profane German, but after their discoverer, one of the members of Stuart's second expedition. As we landed from the train we found the platform redolent with Afghan, impressing on us the fact that Hergott is one of the leading caravan centres in Australia; for it is the point where the main stock-route to western Queensland branches from the railway-line. Until recently all communications to the back blocks of Queensland, even the customs' books and police officers, were sent from Brisbane *viâ* Melbourne and Hergott, a journey of 2,553 miles, including 330 by cart, to reach a place

only 530 miles from a station on the Queensland railways.

The township of Hergott is small, and its few sights are quickly seen. The best view is from the verandah of the hotel; but some of my companions were certainly disappointed even with the best. The view embraces a wide tract of the flat type of desert country. The first impression is of dreary monotony and aching barrenness. The ground is a waste of sand and pebbles, with an occasional bush, which appears to have escaped the voracious camel by successfully shamming death. In the distance, a thin line of scattered gum-trees marks the course of the Frome, at the foot of some low cliffs of desert sandstone. But these cliffs, with the level plateau behind them, serve only to emphasise the flatness of the landscape. The cairn of the Trigonometrical Survey appears, by contrast, as a noble pile—the one vertical feature where all else is horizontal.

But in spite of the unpromising elements in this view it has a beauty of its own. There is a fascination in its breadth. The wide plain, the low horizon, and the magnificent expanse of the sky give a sense of joyful freedom. The pure colours at dawn and sunset, the fine atmospheric effects, the thatched, mud-walled huts of the Afghan camp and its turbaned inhabitants, all give the country an Oriental aspect. Watching the desert at sunrise, and the soft, rich colours

in their rapid play on plain and sky, I felt thrilled again by the weird fascination of the desert, and impatient to follow the great Queensland road down to the Frome, and over the table-topped hills into the haze-filled basin beyond.

This desire to get away from Hergott is not to be taken as any slight on the town. For our feelings towards it are of the friendliest. It is true that the soil around looked the most arid and hopeless we had seen on our journey. We cannot actually recommend Hergott as the site for the Federal capital, but we should like to. Citizens, after all, are the most important element in a city, and it would be hard to find a town with kinder, more hospitable, and more helpful residents than those of Hergott. We took on with us feelings of warm gratitude to Dr. Kennedy, to the station-master, and to Mr. Welsh, the chief storekeeper and business agent. The last, as agent to Mr. Helling, of Cowarie, had arranged the hire of our camels; but he also helped us in many ways quite apart from business. He placed his time and buggy freely at our disposal. He drove us to see the wells, the Afghan camp, and the humble thatched sheds that serve as mosques, wherein the camel-drivers lounge through the heat of the day. The maxim that "to labour is to pray" is not shared by the Oriental. The Mahometan notion is rather that worship is compatible with lounging in the coolest place available;

and though the Afghans at Hergott cannot get the heavenly coolness of a well-built Arab mosque, they have erected the coolest building in the town.

Heat is the plague that troubles the kind inhabitants of Hergott; it was the one topic of conversation, as drought held the monopoly of complaints. We had reached Hergott at the end of a heat wave, and the heat was certainly intense. At first we suspected the dining-room of being also the kitchen, and that our steaks were fried by being left on the table for the climate to cook them. The room felt like an oven, and out of doors the sun was so powerful, that the shade of the verandahs was the only refuge left to us.

The people of Hergott are proud of their heat. "The hottest place in Australia" is asserted by the more modest of them. "The hottest place on earth," say the others; while I heard it hinted that not even down below is there any heat as unbearable as that experienced when, in midsummer, a north wind drives a fog of hot, desiccating dust across the Hergott plain. But the residents enjoy the heat, and it is of a type, where protection from the sun is needed for comfort rather than for security.

At Jibuti in eastern tropical Africa, ten minutes' midday exposure, without a hat, is said to be inevitably fatal. But in Central Australia even newcomers, like ourselves, could go about hatless for

longer periods without feeling any ill effects. We expected to find every one hating the heat and devoting their utmost ingenuity to combat it. As the terai hats of tropical Africa and India are made of two layers, we expected to find at least a three-storied variety in use around Lake Eyre. Green umbrellas we thought would be man's constant companion, and after Sturt's experiences, we should not have been surprised to find advertisements of inks guaranteed to remain liquid through a Central Australian summer, and pencils of plutonic graphite recommended for use in the Lake Eyre basin.[1] But, on the contrary, the residents adopt no special precautions against heat. Our efforts to buy a sun-umbrella were in vain; one storekeeper assured me that they were rarely used north of Adelaide.

Houses are built of corrugated iron, and not one in a dozen condescends to a verandah. Instead of stirrups being made of wood or leather, as in countries where heat is unpopular, they are always of naked iron, with a broad base to collect as much waste heat as possible. My camel saddle had a thick, bare, black iron bar in front, for use as a holdfast when mounting and as a hand-rest when driving. I cannot recommend it for either purpose; but it was a certain preventive against chilblains. Black leather

[1] I have been seriously assured that Sturt could not keep a diary through the hot weather, as the heat softened the lead in his pencils.

is the usual material for boots and leggings; and I am convinced that, when the residents go to church, they go in black frock-coats and silk top-hats.

But in spite of heat, the people looked extremely well. The children were hardier and less anæmic than those at Adelaide. Dr. Kennedy assured me that there is no illness in the district, and that his post would be a sinecure, were it not for ophthalmia and other ailments of the eyes. To my surprise, we found the men working in the open air at severe manual labour, without adopting any precautions or special clothes. Simple slouch felt or thin straw hats are generally worn, and our cook defied the sun in a black hard felt "bowler"; yet notwithstanding the neglect of ordinary tropical precautions, every one looked in the best of health. The men are bronzed and tanned; but one is glad to miss the sallow complexions and wan faces, that Europeans show in tropical African coast towns.

The tolerance of heat shown in this part of Australia certainly supports Sambon's theory in regard to acclimatisation. Sambon holds that there is nothing to prevent Europeans living and working, as well as any black race, in the hottest of tropical localities. He maintains that the supposed unsuitability of the tropics for European settlement is due to disease and not to climate, and that as the special, tropical diseases are due to germs, they may be cured or

prevented when the life-histories of the germs are known.

The sight of white men engaged in severe manual labour, under the midday sun in the hot climate of the Lake Eyre depression, certainly suggested, that a "White Australia" is no impossible ideal for even the hottest regions of the centre.

Fortunately we were not compelled long to endure the heat of Hergott. We arrived after dark on Saturday, and expected that we could do little next day. But apparently we had left the Sabbath somewhere south of Quorn. Mr. Welsh understood how important it was for us to lose no time; so on the principle of "the better the day the better the deed" he speeded his parting guests with the truest hospitality. Thanks to him, we got our kit and camels loaded up early in the afternoon, and within twenty hours of our arrival at Hergott, we had the pleasure of seeing our nine camels start northward for our first camp on the Frome "river." We followed after tea, in two buggies, one lent and one borrowed by Mr. Welsh, and we caught up with the camels on the banks of the Frome. Here we camped beside a soakage, where a sanguine black man was trying to establish a market-garden. A Chinese had tried this forlorn hope some years before, but the newcomer had the advantage of a more cheerful disposition, than any Chinese has had since Confucius. We asked him to show us his garden. He pointed

Preparing to Start, Hergott Springs.

Blacks at Kilalpaninna.

below the sand, and explained, with peals of laughter, that three weeks before a dust-storm had buried his beds and crops. He seemed to regard this playful frolic of the wind, as one of the merriest of jokes. He called himself a Russian Finn; but such levity in misfortune would have destroyed our faith in his nationality, quite apart from such a detail as the colour of his skin.

Before starting on our journey, it may be well to give some brief account of our equipment. Most of our stores were bought in Melbourne, partly, as it would have been unwise to trust to a town unknown to us, and partly because it was best to have them packed under our own supervision. The goods were supplied by Messrs. Moran & Cato, who spared no pains to give us reliable material; the boxes were so well packed that there was not a single breakage. We found afterwards, that we could have got most of the material at very reasonable prices at Hergott Springs, where we obtained our flour, some fresh meat, baking powder, and sundry other items. The usual food allowance on the back stations consists of 10 lb. of meat, 10 lb. of flour, 2 lb. of sugar, and $\frac{1}{4}$ lb. of tea per man per week. But for such a party as our own, I thought it preferable to have a more varied and interesting diet. Accordingly, the following daily ration was provided for each man:

	oz.
Tinned meat	8
Bacon	$2\frac{1}{2}$
Sardines	1
Vegetables—	
Potatoes	5
Onions	2
Haricot beans	4
Desiccated mixed vegetables	1
Oatmeal	2
Flour	12
Biscuits	8
Tea	$\frac{1}{2}$
Cocoa	$\frac{1}{2}$
Butter	$\frac{1}{2}$
Tinned milk	1
Sugar	3
Fruit—	
Jam	4
Dried apricots	2
Figs, raisins, dates	2
Lime juice	1
Total	60 oz.[1]

In addition, we had the usual condiments and sauces, and, on starting, each man received a box of bovril, emergency tabloids, and some chocolate. We were provided with food—including stores bought on the way—at the rate of over 4 lb. per man per day. The supply was certainly adequate, and as soon as our constitutions had accommodated themselves to the heat and camp life, most of us added to our weight. The only articles of food which ran short were tinned milk, meat, and sugar,

[1] Or $3\frac{3}{4}$ lb. per day per man.

of which last we consumed an unexpectedly large amount.

I had been told before starting, that it was absurd to take tinned meat into the cheapest meat-producing area in Australia. But I did not like to trust entirely to local supplies; so we took up tinned meats to the extent of half our estimated requirements, trusting to procure the other half by buying fresh meat at stations, and by shooting rabbits, birds, and game. But except at Hergott and at the Peak Station, twelve miles before we reached our journey's end, we had no opportunity of getting fresh meat; nor was the wild meat supply more reliable. We did not kill a single rabbit nor see a single kangaroo or wallaby; and the number of birds killed for food would not have kept us long from starvation. Accordingly we had to manage on our daily ½ lb. of tinned meat.

The rest of our luggage consisted mainly of scientific apparatus and collecting material. The total weight came to about 30 cwt., which was packed on five camels, giving them an average load of about 6 cwt. It was of course advisable to keep the number of transport animals down to a reasonable minimum, because every additional camel meant extra delay in loading, and in mending broken nose-strings, and an increased demand on a possibly limited water supply. So the camels started fully, but not overloaded; and the weight of food had diminished before the loads were weighted with fossils, or we had reached the

country where we had to carry a heavy burden of water.

That our supplies lasted throughout the expedition, was largely due to the care with which Voss Smith looked after them. He acted as our quartermaster, and served out the stores to the cook. He did his work with such judgment, that the sugar was the only article of food which was used up before the end of the journey. As we expected that the water would generally be saline or alkaline, we started with a liberal supply of lime-juice and vinegar. We took sardines, because they are a convenient food to take with vinegar, and we trusted to a daily dose of acids to neutralise the alkaline effects of the water. Our fruits we took in the form of jam and desiccated apricots, with some Mildura figs and dates to eat on the march. Of alcoholic liquors we had none.

Our meals were an early breakfast, between half-past five and half-past six; during the morning we had a few biscuits with some dried fruit. Lunch was between twelve and one o'clock, and supper immediately after sundown.

The ordinary camp equipment was scanty: we took two tents for shelter during dust-storms; but they were only used at one camp. We had two tents of mosquito netting, each 6 feet long, by 5 feet high, by 4 feet wide. They were intended as a protection against flies, during such work as skinning birds or drawing maps; but the flies troubled us so little that veils were sufficient;

and the fly-tents were never used for their original purpose.

Our party consisted of nine, exclusive of aboriginal guides, who were engaged from time to time. Mr. H. J. Grayson, Assistant in the Geological Department of the Melbourne University, was second in command ; he supervised the whole of the packing and preparation of the equipment, and acted as general storekeeper ; his special scientific work was the study of the fauna in such pools and water-holes as we met with. Five undergraduates of the University, four of whom had done the full geological course, also gave me the benefit of their help. They were A. J. Donaldson, who acted as botanist ; E. B. Dow, who undertook the study of the sand-dunes and collected mammals ; C. M. Lyons was ornithologist ; P. Guy Smith was entomologist, and took most of the observations for altitude ; F. Voss Smith collected crustacea and other invertebrates. In addition to the scientific work, each of the members of the expedition did a share in the camp work. My companions generously undertook the whole of this drudgery, leaving me free to devote my attention, almost uninterruptedly, to geological work.

The most important decision we had to make, in reference to the organisation of the caravan, was as to transport. Asking advice from men who knew Central Australia, I found a widespread prejudice against camels. I was strongly advised

from several quarters to take horses in preference. The possibility of being able to travel with a waggon or with buggies was most attractive; but fortunately, a prejudice of my own against that helpless, hysterical, and fragile animal the horse, led me to reject this advice and decide for camels. Through the kind agency of Mr. Charles Winnecke, Mr. Welsh of Hergott engaged nine camels for us, from Mr. Helling, of Cowarie Station. One advantage of going in midsummer was that, as no one else was travelling, there was an abundance of camels disengaged. Our animals were well selected, did their work well, and got through without accident.

Camels were first imported into Australia in 1846; nine were then purchased in the Canary Islands by two brothers named Phillips.[1] Eight of the camels died during the voyage. The one that landed in Australia was purchased by J. A. Horrocks, of Penworthan, and was used by him in his journey in the Lake Torrens basin. It was while mounting his camel, that this promising explorer met with the fatal gun accident, which brought his expedition to an abrupt conclusion.

The next importation of camels was in 1860, when twenty-four were obtained by the Victorian Government for the Burke and Wills expedition.

[1] For many of these details I am indebted to N. E. Phillipson, "Camels in Australia," *Proc. Roy. Geog. Soc. Austral.*, S. Austral., Br., vol. iii. (1891), pp. 83-92.

Some of these camels accompanied Burke and Wills across the continent, and thus proved the value of camels in Australian exploration. Sir Thomas Elder accordingly decided to adopt camel transport on a larger scale, and he bought a hundred and twenty camels, which were landed at Port Augusta in 1866. They were used in laying the trans-continental telegraph-line and on work in the pastoral districts round Beltana and Blanchewater. In 1884 N. E. Phillipson imported a batch of two hundred and fifty-nine camels. They and the Elder consignment are the foundation of the existing Australian herds. The number of camels in Australia has been steadily increasing; and at the present time there are said to be fifteen hundred in South Australia, over eight hundred in New South Wales, and there were four thousand in Western Australia in 1896.

The use of camels has proved a great success. Owing to them, areas have been settled which otherwise must have remained useless; and during the drought of 1881 they enabled the population of the Albert Goldfields to be rescued when endangered by the failure of the local water supplies.

I had looked forward with interest to a comparison of the systems of camel transport in Africa and in Central Australia, having once taken part in driving a caravan of a hundred and ten camels through a swampy part of East Africa, haunted by the tsetse fly. It was not a pleasant task for the members of the expedition, and it was fatal to

most of the camels. That experience of the camel had left me with the view of the animal expressed in Kipling's masterly study "The Oont."

In preparation for that earlier expedition, I had almost learnt by heart the chapters on the camel in the War Office Manual on Transport. One passage in that manual asserted that "camels cannot stand much work in a hot sun"[1]; and as camels would be no use to us unless they could stand work in a very hot sun, I looked with some anxiety to see how the camels, at Hergott, had withstood the heat wave of the week, previous to our arrival. To my relief they were in excellent condition. They were larger than the ordinary Somali camels, and apparently all belonged to the Scinde breed. Their hair was long and hung in scattered patches, as if, to make up for the scanty feed near Hergott, they had been browsing on one another's fur.

There were three principal points in a camel on which the War Office lay stress in its advice as to their selection. Intending purchasers are warned never to buy camels with broken jaws; secondly, to bear in mind that the abdomen should be well rounded, as "it is a sure sign of a healthy appetite"[2]; the third point to notice is that "the limbs should be strong and well attached to the trunk." So far as we could discover, the nine

[1] Major D. B. Burn, *Notes on Transport and on Camel Corps.* London (1887), p. 176.
[2] *Ibid.*, p. 125.

camels selected for us had not got broken jaws; we were not particular about the rounded abdomen, for camels with a healthy appetite would have a poor chance of satisfying it in the country to which we were going; and we were glad to see that all the available camels at Hergott had their limbs attached to their trunks. Accordingly, we accepted the camels recommended to us, and throughout the expedition they did their work well. They carried their 6-cwt. loads with ease, except, occasionally, over bad sand-rises. They ate any food that came in their way, or fasted like philosophers when there was none. As Major Burn tells us, "all is food that comes to the tooth of the camel. His favourite food is thorn, wormwood, thistle, and coarse, prickly, saline grasses."

It is reported in Central Australia that the camels there have acquired a taste for barbed wire, and that a string of camels can be tempted up a difficult hill by dangling a coil of barbed wire in front of them. As regards water, the War Office Manual tells us that "camels are not particular as to the water they drink; they will even drink stagnant water, but clear water is desirable." Ours had long since ceased to be fastidious as to the quality of their water, and their demands for quantity were very moderate. At Hergott they were watered daily, and it took a little time to break them of this inconvenient habit. But they soon went for a couple of days without water, and, later on, would abstain for several days without

suffering. We could no doubt easily have trained them to go for much longer periods. In Tietkin's journey with the Elder Scientific Exploration in 1891-2 his camels marched 537 miles in thirty-four days without a drink. Phillipson kept a herd of camels without water in a sand-hill country for two months.

These feats probably hold the records for camel abstinence from water. In East Africa a fortnight is generally regarded as the maximum for which a camel will go waterless in a dewless country, without injury. As to the quantity of water required, we found that our camels would work well on three gallons a day; but they liked to have seven or eight gallons, and they had that amount when the supply was sufficient. Even the larger amount is very moderate when compared with the requirements of a horse. Sturt tells us[1] that once he had to limit his horse to six gallons a day, "but where he had been in the habit of drinking from twenty-five to thirty, so small a quantity would not suffice."[2] As a camel will carry from three to four times as heavy a load as a horse, there can be no question as to its superiority for Central Australian transport.

Even camels, however, need reasonable treatment. They have had a bad reputation, partly

[1] C. Sturt, *Narrative of an Expedition into Central Australia during 1844-6* (1849), vol. i. 278.

[2] This amount (250-300 lb.) is not abnormal, for Mr. A. S. Kenyon tells me that thirty gallons a day is the summer allowance for a horse in the mallee country of North-western Victoria.

Our Baggage Camels.

based on the collapse of the camel trains during the Nile Expedition of 1884.

The Intelligence Department had certainly done its best to warn the authorities of the chief causes of disease amongst camels and to suggest practicable remedies. Its manual mentioned, amongst other causes of disease, the fact of camels "being slow feeders," a failing which could be obviated by boiling their food for some hours. Another cause of disease is insufficient rest, which the manual proposed to remedy by the instruction that "silence should be maintained at night, or the camels will not obtain the rest they require."[1] We did not boil our camels' food, nor issue a general instruction, "Don't make a noise, or else you will wake the camel." Nevertheless, our nine camels survived the expedition, and we left them at Warrina in nearly as good condition as when we had started from Hergott.

The proverbial viciousness of the camel, of which I had seen several illustrations in East Africa, is not a leading trait in the Australian camel. We had one troublesome animal, whom we named "Fireworks," because he occasionally went off, as such. The rest we named "the eight saints," from their sweet tempers.[2] Our camels never fought, they rarely bolted, they never bit, and their only objectionable habit was spitting

[1] Burn, *op. cit.*, p. 176.

[2] I have heard since our return that the eight camels were named after the university lecturers, no doubt from the same reason.

their cud upon us, if they considered they were being over-loaded.

In regard to the weight of camel-loads, opinions and practice differ considerably. We were variously advised that from 4 to 8 cwt. was a reasonable average load. Phillipson reports that one of his camels carried a load of 12 cwt. for more than eight miles, over steep sand-hills, without showing signs of fatigue. The average Russian load is from 7 to 8 cwt. The Afghan load also is about 7 cwt.; and we found that 6 cwt., exclusive of the weight of the saddle, was not too heavy for most of our camels.

CHAPTER IV

ON THE QUEENSLAND STOCK-ROAD

> Ye have but my sun to dare,
> Ye have but my sands to travel:
> Go forth, for it is there!
>
> KIPLING.

BEFORE starting on our march next morning (December 16), the Government buggy drove in to our camp upon the Frome. It had been sent by the kindness of Mr. J. W. Jones, the head of the South Australian Water Supply Department, to drive some of us to the Clayton, and thus to ease our first day's journey.

I was glad to avail myself of Mr. Jones's kind arrangement; Grayson, Voss Smith, and Donaldson drove with me, leaving the others, with Steer and a black boy, to bring on the camels.

The day was hot and oppressive, and the sky covered with clouds of that ugly black and white grey so common in Australia. We drove from our camp beside the Frome on to some low cliffs of Desert Sandstone. The chief view from the summit was westward, over the basin of Lake Lettie to a tableland of Desert Sandstone, with a skyline notched by gullies. Eastward were three

low bluffs, their faces white with gypsum, and we drove over to see them. From the top, we had a wide and dismal view across the plain, its melancholy monotony broken only by the table-topped hills of Desert Sandstone, beside Lake Harry.

The one incident in our drive was overtaking a team of eighteen horses, hauling a waggon with five and a half tons of iron casing, for an artesian bore. The load was in charge of two white drivers and a black boy. The head-driver was walking, carrying a heavy stock-whip. His flannel shirt was thin, and his head was protected merely by a broad-brimmed hat, of the thinnest straw. In tropical Africa, his clothing would have been regarded as quite inadequate protection against the sun; but he seemed to find it sufficient, as our cook did with his hard, black felt hat.

We reached the Government boring depôt at Lake Harry about noon, and my companions took photographs and walked up the adjacent hills. The caravan did not reach the station till after six, when Dow, Lyons, and Guy Smith came in, tired by the annoyances of a first day's march, which is generally the most trying; for the camels then are slack, and yet frisky, after their long rest; the new ropes stretch and work loose; the saddles do not fit properly; the loads are badly balanced and slip repeatedly. Twice during the march a load fell, and had to be untied and the camel reloaded. As the caravan reached Lake Harry,

a choking dust-storm swept across the plains: so the men straggled into the depôt, tired and disappointed with their first experiences of the country, and a little disgusted with camel transport.

Mr. Brown, who was in charge of the station, did everything he could to make us comfortable, and next day the conditions were all more encouraging. The storm had cleared the air, so the heat was less severe, the loads rode better, and our route march lay across less dreary country

For the first few miles of the way, the broad, salt-crusted bed of Lake Harry lay on our right; to our left were flat-topped hills of Desert Sandstone. We crossed part of the broad Illusion Plains, so named by Parry, who first visited them in August, 1858; and, as on the occasion of his journey, the mirage effects were of unusual vividness. At sunset we reached a large hole, filled with fresh water, in the bed of the Clayton River. It was a picturesque situation. We pitched camp beside some gum-trees, and our sportsmen did good practice on the birds—teal, ducks, goliah-parrots, top-knot pigeons, and mudlarks—that swarmed around the pond. On the opposite bank of the river was the station of Clayton. It looked as if it had seen better days; and it was the last occupied cattle-run we passed till we reached the trans-continental road, to the west of Lake Eyre.

In the evening, Mr. Hill, the owner of the

station, accompanied by a friend, came down to show me a fossil kangaroo tail, which they had found on Cooper's Creek, near Innamincka. I ventured to express the opinion that it was a piece of fossil wood; but this view was regarded as so preposterous that I did not press it, as the men had seen many more kangaroo tails than I had. They gave me a very gloomy account of the country; and Johnston, our second visitor, told me that he had been in those parts for six years—"and that was six years too long," he added, sadly. He had once started with a mob of cattle for Innamincka, a locality on Cooper's Creek, near the border of New South Wales; he had taken thirteen months on the journey, and had lost practically the whole of the stock on the way. He had to stay a long time at one water-hole, unable to move, because the pools had dried up both in front and behind; he had to stay in his camp, watching the bullocks die of starvation, till a fall of rain enabled him to escape from his desert prison. He told some sad stories about the loss of cattle on these marches; five years before, a dust-storm had swept over a mob of five thousand cattle coming down the Queensland Road; the storm stifled most of them, and the rest were destroyed by a panic, as, in the darkness, they dashed into a salt pool and were bogged. In addition to such accidental losses, there had been terrible devastation all through the country, as a consequence of the

drought. The Cowarie station, my informants told me, had now only forty or fifty cattle, where it formerly had eight thousand; the Clifton Hills station was estimated to have once had four hundred thousand cattle, but its vast herds were now reduced to a few thousand.

Next day we crossed the dry bed of the Clayton, and marched northward on to barren, sand-strewn plains. We were now well out on the Queensland Road, and for the first few days of our journey, we were lost in admiration at the pluck of the South Australian people in settling here, and at the enterprise of the Government in opening a practicable route across such a desert: it seemed incredible, that stock-raising could ever have been successful in such a country.

For seventy-five miles, our journey lay mainly across sand plains and "gibber" plains; these last have a hard brown soil, littered with rough fragments of schist and quartzite. The level of the plains is broken at intervals by conical and table-topped hills, remnants of the sheet of Desert Sandstone, that once covered the whole of this district. Here and there lines of sand-dunes run north and south across the country with the regularity of a railway embankment. The stony plains and the dunes are both so barren that we felt that the Society for the Prevention of Cruelty to Animals should stop any attempt to tantalise cattle by setting it to graze on such a pasture. But the clay-pans and the dry lake-beds with their

sheets of salt crust are even worse. Mr. Grayson, who speaks with professional experience of horticulture, remarked that he had seen no good agricultural land since we had left Quorn.

The fact that most of this land had been "taken up," and at one time held on lease, shows that the country is better than it seems. Its present barrenness, compared with the descriptions of its appearance after good rains, helped us to understand the different accounts given of it by the first explorers. Sturt must have crossed it when it was much under its present conditions, so he called it "Stony Desert," and applied to it other opprobrious epithets. Whereas his successors, such as McKinlay and Davis, must have seen it after heavy rains, for they spoke of the country in glowing terms, and described it as a wonderful land of meadows and lakes.

These contradictory descriptions were no doubt equally true. Drought always causes sterility, while moderate rains on the rich fallow soils of arid regions produce luxuriant plant-growth. As a consequence of its usual aridity, the soil in a desert, if of suitable texture, becomes especially fertile when watered. All soils, containing much loam or clay, contain sufficient materials to nourish an indefinite number of crops; but the bulk of these materials are not immediately available as plant-food; they must first undergo slow processes of chemical change.

In a rainy country, these changes, which make

the materials soluble and therefore capable of feeding plants, make them also liable to be washed out of the soil, as soon as they are adapted for plant-food; or they may be carried downward, below the level at which ordinary crops can reach them.

But in arid regions, where all the rainfall is returned to the air by evaporation, the available plant-foods in the ground remain near the surface, and gradually accumulate during long, restful periods of drought, when no plants can grow to feed upon them. Hence, excepting where the ground is covered by a layer of stones or a sheet of quartz sand, or is poisoned by noxious salts, arid areas always have rich soils. They need only water to unlock their rich reserves of food. It is the water of the Nile, not the silt it brings with it, that maintains the fertility of the irrigated districts of Egypt. The change wrought by the Mormons on the former bed of the Great Salt Lake of Utah, where they turned a desert, as barren as the barest patch in Lake Eyre, into a prolific market-garden, shows what can be done with soil that looks the least promising.

The recuperative power of the desert, when watered after a long period of drought, must be seen to be realised. Good rainy seasons would soon work a vast change in the aspect of Lake Eyre. But whether the prosperous seasons between 1879-95 will be restored, except by a succession of unusually good seasons, is a little doubtful.

Since the country was first settled a new factor has been introduced. Rabbits have devastated the land, cut off the herbs and bushes, gnawed the underground stems exposed by the wind, and eaten the grass down to the roots. Under former conditions the rain acted as a stimulant to rouse the country from its long rest during the drought; but now that starving stock and rabbits have cleared the herbage to the roots, there is little left for the rains to revive. Seeds are lying dormant in the ground, but the regrowth must take place far more slowly than under the old natural conditions. This idea seems widely shared by those who know the country best, and accounts for the fact that so many of the stations have been abandoned. This is an "all chuck it country," an Afghan said to me at Hergott, in explanation of the diminished trade. But the trade is still considerable. A mail runs, or is supposed to run, weekly to Queensland, and cattle are driven along the stock-route in enormous mobs. For the route is kept open to cattle traffic by the series of flowing wells, that have been bored by the South Australian Government, at convenient intervals along the road.

There are bores for the first ninety miles along this route at Hergott, Lake Harry, Dulkaninna, and Kopperamanna. The bores are let on lease, and the holder takes toll for all the stock watered at them. The charges are 2*d.* a head for camels, 1*d.* for horses and cattle, and 9*d.* the hundred for sheep. Thanks to these bores, cattle can be driven

from Queensland to Hergott even during prolonged drought. According to Herr Vogelsang, the manager of the out-station near the Kopperamanna bore, 14,000 head of cattle and 12,000 sheep passed his station between August, 1901, and December, 1901 ; whereas, but for the flowing wells, all stock movements must have ceased long ago.

The wells are often very productive. According to Mr. Jones, the South Australian Conservator of Water, the yield of the Kopperamanna bore is 800,000 gallons a day, and that at Dulkaninna is 1,000,000 gallons. The depth of the bores is respectively 3,000 and 2,200 feet, and the water comes up hot and steaming. At the Mirra Mitta bore the water has a temperature of 190 degrees, and will make good tea without any further heating. But unfortunately, the water is charged with various salts, especially soda, so that it is not good for drinking, except as tea. It is often said to be useless for ordinary agricultural purposes, and so, no doubt, it may be, unless treated with special manures, or for growing special salt-living plants. Accordingly, what is not drunk by cattle and sheep is allowed to run to waste.

The country along the Queensland Road has long been well known; at one time it was all leased as cattle-runs, of which too often the only relics are dilapidated wire fences, and the boundaries of the leases, which exist only on the maps. The country has been trigonometrically surveyed by the South Australian Lands' Department; and as

we rode along, Steer told me stories about the hardships the surveyors had had to undergo, when they "trigged" the district. The verb "to trig" was new to me, and I had to think for a moment, before I guessed that it was short for "to make a trigonometrical survey." Steer said that the head of the survey party was killed by overwork and over-exposure.

Our fourth camp along this road was on an open stony plain near a pile of black ironstone. It is known as Milners' Pile, after two brothers, who, in the early days, drove some cattle northward to Queensland by this route, and built the cairn to help them find the road on their return. But they fell among the blacks; one of the brothers was speared, and the other for a time went mad with rage and thirst for vengeance. He ran amuck with a pistol and cutlass among the aborigines, whom he suspected of the murder.

We camped north of the Pile, in sight of the dark timber-belt of Cooper's Creek. But we were still out in the plains, as we found to our discomfort, when the wind rose at sunset and swept a slow, steady drift of sand upon the camp. The night was close and muggy; and at sunrise the whole sky was covered by a vault of thick grey clouds, unbroken except for a narrow slit along the eastern skyline and an eye-shaped gap above. Through this gap passed a shaft of light, which was reflected as the base of a rainbow from a mist-band in the west; the coloured band was vertical

and part of so large a bow that it appeared quite straight. It stood where the night before we had seen a gleam of zodiacal light, and the two reminded us of the pillar of fire, that guided the Israelites in the deserts of Sinai.

The desert sunrises were, on the whole, a disappointment; but that morning the colour effects were magnificent. The belt of sky seen on the eastern horizon was greenish yellow; the one gap in the clouds above it was a pure soft green. The lowest layer of stratus clouds was vivid scarlet, fading gradually upward to a delicate pink. Still higher followed a belt of glowing yellow, passing to the bluish grey of the main cloud-vault, below which a few outlying cloudlets were tinged with an Alpine rose-red.

An hour after sunrise the last of the bright colour had faded from the sky. Once or twice a shaft of sunlight found its way through a gap in the clouds, and struck the western sand-hills with a fierce glow, like the flash of a searchlight; but as the sun rose higher, these breaks in the clouds closed up, and there was nothing to relieve the monotony of the leaden grey of the sky and the parchment-brown of the plains.

About eleven o'clock we entered the timber-belt of the Barcoo or Cooper's Creek, a locality famous in the annals of Australian exploration; for, Burke and Wills, on their return from the first journey across the continent, both died upon its banks. The Cooper was waterless when we crossed it; the

river-flat is some ten or twelve miles wide, but at the time of our passage there was no channel which we could definitely select as the line of the river. The Cooper only flows at long intervals; then it comes down in flood, spreading for miles over the lowlands. These floods deposit a layer of fertile mud, as the Nile does in Egypt; and this mud-covered plain supports a thin forest of box, mulga, and acacia. This "timber land" has a striking general resemblance to the East African acacia scrub. The trees grow as tufts of irregular gnarled stems, thick below, but rapidly tapering upward. Near the ground the stems are dark grey to black; above they are white, often with a greenish tinge, while on the uppermost branches the new bark is a pinkish red. One species of box, a eucalyptus, has acquired the growth of an acacia; while another tree, instead of having its foliage in the typical mop-like clusters of the gums, has long drooping leaves and branches like a weeping-willow. The trees, on an average, are only about twenty-five feet in height, but they looked exquisite and impressive in contrast to the treeless plains. Up to the level of from four to six feet above the ground all vegetation has been killed by the floods, which have cut off the lower branches and shrubs as sharply as the deer clip the trees in an English park. None of the trees gave any shade by their leaves, and when we rested for lunch, we crouched under the shelter of thick branches.

Birds were more numerous here than in the open plains; and after our midday rest Dow, Lyons, and Donaldson went off into the scrub to shoot, while I walked ahead to the mission station of Kilalpaninna, to arrange for the arrival of the caravan. This shooting excursion resulted in some trouble to our friends of the mission. One of our sportsmen, in the excitement of the chase, crossed the "great Queensland Road" without noticing it, and, being thus on the wrong side of our route, got bushed. He found the track leading to the off station at Etadunna, and followed it till dark, when he wisely sat down to wait for help. As soon as his absence was reported at the station, a search party was sent out. A black boy discovered the track of our missing companion, which he distinguished from those of the rest of the party, by a flaw in the sole of the boot.

Herr Reuther, the manager of the mission, and Mr. Hillier, an English resident there, went out at sunset with another party, and, following the trail by firesticks, found our "lost sheep," as the black-fellows afterwards called him, snugly asleep under a bush.

The Lutheran mission station of Kilalpaninna, on the northern edge of the Cooper Creek timber, is a veritable oasis in the wilderness. It stands on a high sand-dune, surrounded on three sides by a lake, shaped like a horse-shoe, once no doubt a bend of the Cooper. The lake, unlike most of the so-called lakes in this country, actually contains

some water, or at least some brine. When full, the lake water is fresh, and photographs taken of the mission at such periods show that the situation is then quite picturesque. But at the time of our visit the hills were bleak, bare sand-dunes, and most of the lake had been replaced by a dry clay-flat; so there was little in the scenery to distract attention from the mission and its work.

Kilalpaninna is a mission to the Central Australians, founded by the Lutheran Church in 1866. The mission leases a thousand square miles of country, and holds a half-share of the Kopperamanna bore. It has, therefore, an industrial as well as an evangelical side, and is one of those exceptional philanthropic institutions which are self-supporting. The staff of the mission consists of two missionaries, Herr Reuther and Herr Siebert, and three assistants, who manage the stock and the out stations. The natives on the mission lands number about two hundred, and a more contented and prosperous black population it would be difficult to find.

It was upon this station that I first had the opportunity of observing the Australian aboriginee,[1] and contrasting him with the African negro. The points of resemblance and contrast between them are very striking. The Australian has some

[1] In Australia the term "native" is always used for white men born in Australia. The original inhabitants are called Black-fellows or Aborigines; from the last term is derived the singular Aboriginee.

The Mission Station at Kilalpaninna, across the Dry Bed of the Lake.

of the characteristics of the negro; but he appears to me to be essentially Caucasian. He has the kind-heartedness of the negro, with the capacity for dignity and self-respect of the Caucasian.

The Australian aborigines have been often described as the most degraded of human beings. The work of the Lutheran Mission shows that, given a fair chance, kind treatment, and a suitable education, the Australian aboriginee will develop into an intelligent, industrious, and useful member of society. Some of the black-fellows on the station speak English more correctly than many of the less educated of the white residents in the country; and the fact, that some of them earn wages up to fifteen shillings a week, shows that they prove efficient and steady workers. The honesty of the Kilalpaninna blacks is remarkable in contrast to that of negroes and Asiatics. The beneficial influence exercised by the mission on its black followers renders its ultimate failure all the more pathetic; but failure seems inevitable. The mission is too late to save the tribes from extinction. Of the Tirari, who occupied the eastern shore of Lake Eyre, there are but five survivors; of the Dieri, who formerly ranged over most of the land now held by the mission, there are only some hundred and fifty, who are practically all living under the shelter of the mission. But its protection cannot ultimately save the race, unless the birth-rate can be raised. The natives of this country must once have had large families; for the Kuyuni, who lived

south of Hergott Springs, have a special word in their language for each child in a family, up to the tenth born. But now marriages among the aborigines in the bush are sterile, and even on the station, the birth-rate has dwindled almost to zero. According to Herr Reuther, in forty years' time, the extinction of the native tribes, to the east of Lake Eyre, will be complete.

We saw the aborigines under specially favourable circumstances, for we spent Christmas at the mission, where the festival was celebrated with the old-fashioned German ceremonies and rejoicings. My companions added some corroborees, after the manner of the Melbourne student, which were rapturously enjoyed by the enthusiastic black-fellows. They, in turn, gave us an amusing performance, imitating emus, and a camel, with its Afghan rider, and a caricature of a quarrel between a drover and a squatter. The unalloyed merriness of the black-fellows brought into relief the under-current of sadness discernible in the minds of our hosts. Christmastide and its associations naturally turned their thoughts to the Fatherland, and to the contrast between the lovely German valleys, with their forest-clad hills, and the barren wastes and miserable scrub around Kilalpaninna. The mission service, with its solemn choral and its simple Lutheran ritual, brought back a memory of Herr Siebert's native town, amid the terraced vineyards that slope to the swirling Rhine. It made me realise, as I stepped from the mission church

into the glare and dust of the Kilalpaninna sand-hills, the price the missionaries pay for their devoted service to the last remnants of the people, who once held sway over the eastern lowlands of Lake Eyre.

CHAPTER V

ALONG COOPER'S CREEK TO KOPPERAMANNA

> And through the days when the torrid rays
> Strike down in a coppery gloom.
>
> KENDALL.

DURING our march north from Hergott we had seen nothing to the west higher than a series of sand-dunes. To the east our view had been bounded by a range of flat-topped hills, which form the divide between the basin of Lake Eyre and those of Lakes Gregory and Blanchewater. These uplands are the remains of a broad sheet of Desert Sandstone, which must once have covered the whole of this country; but it is now reduced to a triangle, of which the base abuts against the northern end of the Highlands of South Australia. Thence it tapers northward to a point on the southern bank of Cooper's Creek; while north of the river there are some more hills of Desert Sandstone in continuation of the line of the southern uplands. I was very anxious, before going westward to Lake Eyre, to see the gap by which the Cooper passes through the line of the Desert Sandstone hills. So I

arranged to make a hasty visit there, while my colleagues were resting at Kilalpaninna. Herr Siebert kindly engaged a couple of guides for me, and after two days' stay at the mission station I started eastward along the Cooper.

The weather at the start looked most unfavourable, a strong wind filling the air with a thick dust. I started somewhat reluctantly, thinking that I was giving up a couple of days' rest at the mission station on what would probably prove, owing to the perversity of the weather, to be a wild-goose chase; however, I kept to my purpose. The first part of the route lay over the "sand-hill" country on the northern side of the Cooper. The two guides were mounted on the camel "Fireworks," which, being frisky after its two days' holiday, bolted repeatedly. I was left, on my sedate camel, to follow the guides by their tracks, as best I could. My attention was accordingly concentrated on the ground beneath me, and I soon recognised that the supposed sand-hills were not real dunes, but ridges of loam, with banks of sand along their summits. Instead of the hills being composed of heaps of sand from thirty to fifty feet in thickness, the sand was only some three to five feet thick on the crest, with thinner layers on each flank of the ridges. My examination of the "sand-hills" was not disturbed by any distant views, for the dust-haze obscured everything that was more than a few hundred yards away. After travelling for a couple of miles over the loam

country on the northern bank of the Cooper, the track descended to the timber-belt on its bed. The creek here is a level plain, through which the water of the Cooper, when there is any, runs either in a network of broad, shallow channels, or covers it in a continuous flood. The Cooper, in this part of its course, is not a river or even a creek. It has no definite bed. It is a flood-plain, some eight to twelve miles in width, the whole of which is covered when the Cooper is in flood. The level of the plain is broken by a few scattered hummocks of sand, and a series of shallow depressions that are, apparently, channels cut by the last of the receding flood-water. Several features in this Cooper "timber-belt" reminded me of a mangrove swamp. The box-trees are about the same height as mangroves; the network of dark clay channels, that spreads over the plain, has much the same shape and plan as those cut by the ebbing tidal waters, when they run off a mangrove flat; and up to the level of from four to six feet from the ground, all the vegetation has been killed. The top of the flood-line is here as sharply marked as the tide-line in a mangrove swamp. The ground was littered with dead wood, and in the undergrowth only the young bushes, which have grown up since the last flood, showed any sign of life. The monotony of the scenery was increased by the dust-fog, which generally hid anything that was more than a hundred yards away; but occasionally the larger trees could be seen up to a distance of three hundred yards,

when the mop-headed clumps of foliage loomed through the mist-like dark clouds.

As we travelled eastward, the flood-plain of the Cooper contracted ; the sand-hills on the northern and southern banks were nearer to us, and the haze became still thicker. After a journey of a couple of hours we suddenly came upon the shore of Lake Kopperamanna, where we surprised a party of "native-companions" (*Antigone australasiana*), the only time during the journey that we saw these large dancing cranes ; and, thanks to the fog, we found ourselves close to them before they noticed us.

We rode along the southern end of the lake to the old mission station of Kopperamanna, and then four miles southward to the Government bore. This bore has a total discharge of 800,000 gallons a day. The water, as it comes up, is so hot that I was able to make tea from it directly. The pipe has two outlets, one of which flows into the mission reserve—the other crosses the range and discharges eastward into the estates of Sir Thomas Elder. The bore is leased by the Government, half to the Elders and half to the mission. Most of the water runs to waste ; it is only used when mobs of sheep or cattle are driven along the Queensland Road and by the now small herds of the two leaseholders.

Fortunately by this time we were gratified by a change in the weather. The air had cleared, and when we reached the bore, the dust had settled sufficiently to give a full view of the

surrounding country. A long line of sand-dunes came down from the western uplands, and ended abruptly at the Cooper timber-belt. To the south lay a broad plateau of stony downs, rising gradually to Mount Meyer, and marked by occasional hummocks, such as Trooper's Knob. To the south-east I looked along the broad valley of the Dipulaco, a flat-floored valley running between two ridges of Desert Sandstone to a low gap in the hills above Lake Gregory. Looking eastward along the dark green line of the Cooper timber-belt, you see the gap by which the river passes through the Desert Sandstone ridge, hills of which can be seen on both sides of the river. It seemed quite clear to me that at one time this eastern ridge had been continuous, and that it had been breached by the Cooper, the Dipulaco, and the Mariperanna.

To get a nearer view of the passage of the Cooper through this ridge we rode some miles across the plains to a small knoll of Desert Sandstone at Nungunpurananni, whence we had a much clearer view of the divide between the basins of Lakes Eyre and Gregory. A quarter of a mile to the north-north-east was the ridge of Narikalinanni, which name, according to my guide, means "the place of death and destruction." To the north of this ridge ran the main channel of the Cooper, beyond which we could see the so-called white "sand-hills" of Modawilpanni, and north of that again was a line of brown "sand-hills," which

represented the northward continuation of the Desert Sandstone plateau.

The knoll of Desert Sandstone at Nungunpurananni clearly showed the origin of the "Stony Deserts," an origin that has been much disputed. This problem naturally excited the interest of the early travellers; for these wide wastes of stones are most impressive in their awful desolation and barrenness. The pebbles are sometimes so closely packed that a cart leaves no wheel-ruts; and, as the South Australian police know to their cost, aboriginal fugitives can cross the country without leaving the slightest trace of their footprints. I was told of one South Australian police officer who gained the affection of the aborigines by keeping them well supplied with dogs. His motive, however, was not generosity. He was thus enabled to track the aborigines across the Stony Deserts, as the clumsy dogs disturbed the stones, or put their feet between them and left footprints on the soft clay.

The stones on these plains are angular, and are said in places to fit together with the accuracy of a mosaic; and when the pebbles are thus closely packed, patches of the Stony Desert appear like a tessellated pavement.

Sturt was the first man who gave any detailed description of the Stony Desert, and he explained it as due to the action of a former sea. He regarded "the sandy desert as once undoubtedly a sea-bed,"[1] and saw in each belt of stony desert

[1] Sturt's *Central Australian Expedition*, vol. i., p. 130.

"the focus of a mighty current" sweeping across an old sea-floor.[1] The pebbles of the stony plains, however, show no signs of water action. Sturt's view is an illustration of the habit so prevalent in the middle of the last century of regarding water as the universal geological agent.

The Stony Desert, in fact, is due to the absence of water. The country where it occurs was once covered by a sheet of the rock known as Desert Sandstone, in which there are abundant pebbles of quartz, sandstone, and other hard materials. The Desert Sandstone has slowly decayed under the action of the weather; the loose sand has been blown away by the wind, and the hard fragments remain scattered over the ground. The Desert Sandstone once spread in a continuous sheet all across the Lake Eyre plains; and wherever the waste from the Desert Sandstone has not been covered by later deposits, it litters the ground as the barren Stony Desert.

The sun was already setting, and my guides were fidgeting with impatience, for we had a long journey back through the Cooper timber to Kopperamanna; so we turned our camels northward, and trotted as quickly as they would go through the scrub. After a journey of a couple of hours we struck the track we had used in the morning.

At the Kopperamanna Mission I was hospitably received by Herr Vogelsang, the assistant in

[1] Sturt's *Central Australian Expedition*, vol. i., p. 132.

charge. Kopperamanna had been the headquarters of a large settlement of aborigines; but at present there are only five of them on the station, whereas thirty-five years ago there were sometimes as many as a thousand camped around the lake. Hence Kopperamanna is now maintained as an out-station from Kilalpaninna, and the work there is more pastoral than evangelical.

Vogelsang is one of the lay assistants of the mission, and, judged by length of service, he is the senior man on the mission staff. He is the only member of the party which founded the mission who is still engaged in its work. He went to Cooper's Creek in 1866, and has lived ever since within the ample domain held by the mission, except for an occasional visit on business to the railway town of Hergott. He stuck to his post when the clerical members of the staff withdrew in despair, and it was his constancy and resolution that once prevented the supporters of the mission consenting to its final abandonment.

After dinner this loyal servant of the Lord, in his quaint broken English, told me the story of the mission. It was founded in 1866 by two synods of the Lutheran Church, the Immanuel Synod in Germany and the Australian Synod in South Australia. Two missionaries, Goesling and Homann, with Vogelsang as their practical assistant, were sent from Germany to Adelaide. Here another assistant, Jakob, was engaged, and the party started for the interior to find a suitable

locality for their work. They were first directed to Lake Hope; but it did not appear satisfactory, and they went on to Cooper's Creek, and settled beside Lake Kilalpaninna. About the same time three German Moravian missionaries founded a station at Lake Kopperamanna, ten miles to the east. Both stations were abandoned three months later, owing to the hostile attitude of the aborigines, and the missionaries withdrew to Bucaltaninna, then the most northern of the South Australian sheep-stations. Goesling resigned his post on account of ill-health. The authorities of the mission were not discouraged, and as Homann was willing to return, Koch was appointed to take Goesling's place, and the missionaries went back to Kilalpaninna in 1868. Here Koch died a year later, after having translated the Lord's Prayer, the Commandments, and the Creed into Dieri.

Schoknecht arrived to succeed Koch, but he and Homann again abandoned the mission, this time on account of the limited water-supply. They did not return, as Homann accepted a pastorate in Adelaide, and Schoknecht in Victoria. The Australian Synod thought it better to abandon Cooper's Creek, and make a new start elsewhere; so it founded the Hermannsburg Mission on the Finke River, among the Macdonnell Ranges of the Northern Territory.

Meanwhile, Kilalpaninna was maintained by Vogelsang and Jakob, whose success encouraged the Immanuel Synod to make a fresh effort to

continue the work. A lay missionary, C. A. Meyer, was sent up to Kilalpaninna in 1875, where he stayed, in spite of a disastrous drought, till 1878, when ill-health forced him to return for a while to Adelaide. He was there ordained, and returned to Cooper's Creek with the Rev. J. Flierl, a second missionary, who had arrived from Germany. They rebuilt the station at Kilalpaninna, which they called Bethesda, and abandoned the station at Bucaltaninna. Since that time the work at Cooper's Creek has gone on without interruption. The mission holds a hundred square miles, granted by the Government as an aboriginal reserve, and also three hundred and forty-six square miles, leased as a grazing area, and it has a half-share in the Kopperamanna bore. The working of this great tract of land affords the opportunity of giving the aborigines excellent technical training, and in good seasons renders the mission self-supporting.

CHAPTER VI

DOWN COOPER'S CREEK TO LAKE EYRE

> Not a pool, not a bush, not a house is seen
> Round the parched flats, spread as a lake between.
>
> METHUEN.

THE serious work of the expedition to Lake Eyre began after leaving Kilalpaninna. According to native traditions, reported by Herr Siebert to Dr. A. W. Howitt, many Kadimakara (*vide* p. 4) are buried to the west of the mission reserve, between the Queensland Road and Lake Eyre. The occurrence of fossil mammals in this locality was confirmed, early in 1901, by Mr. H. Y. L. Browne, the Government Geologist of South Australia, who discovered bones there, while examining some reported phosphate deposits on the Cooper.

Our first object was to make larger collections of the fossils, in the hope of definitely determining the age at which the Kadimakara lived, and with what animals they were associated. We wanted also to get further evidence as to the geological relationship of the bone deposits, and especially to ascertain whether they were laid down on the bed of Lake Eyre, when the lake was much larger than it is at present.

After a merry Christmas at Kilalpaninna we arranged to proceed on our journey down the Cooper. We had a pressing invitation to stay longer at the mission; but we did not know how long it would take to reach the collecting-grounds, and so we felt bound to hasten on. We compromised with our kind hosts, and agreed not to leave till after lunch on Boxing Day. At two o'clock Steer brought in the camels, and we began to load them. The heat seemed to us unusually severe, though our friends said it was comparatively cool; but they all kept snugly under the shade of the verandah; and, after starting, we noticed that the guides rushed to the shade of a tree, whenever we stopped to readjust a load or tie a broken nose-string, as if they found it warmer than they admitted.

The first march, as usual, proved troublesome: several loads had been repacked and rode badly; extra water-barrels, together with a sack full of bread and cakes, kindly baked for us by Frau Siebert, had been added to our already abundant luggage; the camels were restive, after their holiday, and two of them succeeded in throwing their loads; but, by beginning with a half-march, all these small sources of delay were discovered without upsetting a full day's work. Next day we were able to load more quickly, and proceed without interruption.

Our route from the mission lay, for the first two days, along the flood-plain of the Cooper,

where the scenery was like that observed during the excursion to Kopperamanna. We crossed a number of waterless lake-beds, where we found the nardu plant. The spores of the nardu are an important native food. King, the only survivor of the Burke and Wills expedition, was kept alive on this food till his rescue by Howitt, but it failed to support his companions.

After a gorgeous sunset, which promised us another hot day on the morrow, we camped during the short gloaming, a mile east of the abandoned cattle-station of Cannatalkinna.

The most interesting fact I observed on this march over the Cooper flats was the extraordinary abundance of old stone-flakes, littered over the ground. These flakes had been used as knives and scrapers by the Dieri. The population in this district has probably always been sparse, and the material of which the implements are made must have been obtained from rocks many miles distant. Yet artificial stone-flakes are scattered broadcast, and quartzite chips could be collected by the bushel.

In the days of the first discovery of ancient stone implements in England, objection was raised that they were too numerous to have had an artificial origin, as their numbers would imply a dense population, or a prolonged occupation of the country. This argument is not yet altogether dead, as I have heard it seriously advanced quite recently. But here on the Cooper, stone-flakes, unquestionably

Leave-taking, Kilalpaninna. The Blacks appreciate the Shade.

of human origin, were littered with the same extravagant untidiness, as are the palæolithic flakes in some English gravels. The fact is probably due to the stone-using people having had no pockets. Steer told me that the natives used to carry about a lump of quartzite and a hammer-stone; and whenever they wanted a flake, they would strike one off the quartzite and throw it away as soon as they had done with it.

Early during our next march we were overtaken by Mr. Hillier, an English resident at the mission station, who had kindly promised us the pleasure of his company for a few days. He greeted us with the most welcome compliment that he could have paid, saying that we were much farther on the road than he expected. He had not been able to start with us, as his horses had to be kept at some distance from the station, owing to the lack of feed in its neighbourhood, and it had taken four days to catch them. Horses have not yet recovered from their racial dislike of approaching camels, a dislike which was known to Herodotus, and used by Cyrus to rout the Lydian cavalry; and Mr. Hillier had to give us a pretty exhibition of horsemanship, in bringing his horses up to the camel train.

After a short march we reached the Cooper, and found that we had passed beyond the broad flood-plain of Kilalpaninna. The river now occupied a well-defined channel from six to ten feet deep, while above the plains sand-capped loam-ridges rose

thirty or forty feet higher. The river-bed, moreover, was boggy, and had occasional pools of brine, from which the mission gets its supply of salt. In some places, on the edges of these pools, fresh water can be obtained by digging small pits, or "soakages." At one of them we met Mr. Bosworth, the last dweller on the Lower Cooper. He was on his way south; for he, too, was leaving the country, as it had now no feed for horses or stock. He expressed his utter disgust with the country, in forcible language, but with Central Australian cheerfulness. As I was doubtful whether the weather that day was warm for the district, or only warm as compared with milder climates, I asked Mr. Bosworth if he regarded it as a hot day. "I do," he said emphatically; "any one who wants it hotter is greedy." After this testimony to the heat of the day, we felt excused for resting during the afternoon. We started again about five in the evening, and soon afterwards found our first fossil bones. They were badly preserved, and they induced us to hasten on to the area, where we hoped to find the bones were more numerous and in better condition. So we resolved to march on to the next water-hole. At sunset we passed some beds of recent limestone at Palankarinna, in which Donaldson found the half-fossilized jaw of a dingo. The night was dark and moonless; but we pressed on till, after ten o'clock, we reached our camping-place beside a large water-hole at Piaranni.

The place-names shown on the map had misled us as to distance; for the water-hole, locally known as Piaranni, occurs at the locality marked as Tilla-tilla, whereas Piaranni is shown farther to the east, at a place known as Pandi-wilpina. We therefore reached our journey's end sooner than we expected, though the flocks of top-knot pigeons and white cockatoos, which we disturbed, had warned us of our approach to fresh water.

At nine next morning we resumed our march, twice crossing the Cooper, and at times marching along its bed. There was a wild wind from the north-west; the heat was oppressive, and the air was so full of dust, that it was as opaque as a Scotch mist. It was the most unpleasant day we had had since leaving Lake Harry, for the conditions were uncomfortable, and we could see nothing of our route. At noon we reached Palankarinna, where a track leads off northward to the Diamantina. As we might want to use this place as a depot, we stopped to lunch and to test the water from its small slow soakage.

In the afternoon, the wind went round to the south, the air became cooler and clearer, and we pushed on along the river. We here left the Dieri country and crossed the frontier of the Tirari, into the country of Emil. He was very proud of showing his country, and pointing out its good features. He dug up a conical piece of yellow sandstone from the foot of a box-tree,

and then presented it to me, saying sadly that it would never be wanted again. He explained that it was a Wommagnaragnara, which, being interpreted, is, "The heart of the snake." It was used at corroborees to make the dark olive-brown carpet-snake, known to the natives as the Womma.

After passing this tree, we left the bed of the Cooper and crossed a plain in a bend of the river, past an old stockyard, known as Emu Camp, to the brine-filled water-hole of Markoni, or Malkuni. We dug some soakages, and, finding a good supply of fresh water, pitched camp in a clump of gum-trees, at the mouth of a dry gully. The situation was picturesque. Behind us rose cliffs of horizontal, bedded loams, commanding a wide view over the district. The Cooper Valley is here a broad deep trench, wherein the sinuous bed of the river is marked out by long reaches of salt water. The pools were alive with many birds; and instead of the usual pigeons and cockatoos, we found ducks, with shags, sea-gulls, and other birds that frequent sea-coasts.

Unfortunately there was no horse-feed anywhere along the river; so, much to our regret, Mr. Hillier had to leave us. Next day all hands set to work, searching the river-bed for fossil bones. Our guide, Emil, soon called me; and, after sundry theatrical attitudes, exclaimed, "Kadimakara!" and pulled out of the mud part of the lower jaw of a Diprotodon. The result

of the morning's work was a good collection of fossil bones of kangaroo, bandicoot, crocodile, mud-fish (*Ceratodus*), and birds. The search, moreover, showed us the conditions under which we should find the bones. So, leaving Mr. Grayson, Guy Smith, and Voss Smith to work this locality, the rest of us started in the afternoon, with one camel laden with water, and another with collecting-cases and food, to search the river farther to the west.

Our guides were Emil (facing p. 178), and Anton (or Anthony), an Urabunna from the country west of Lake Eyre.

Emil was the best and most interesting guide we had during the expedition. He was a man in the prime of life, tall and powerfully built. His face was intelligent and always expressed his good humour, which was not to be perturbed by any amount of chaffing. The use of a nose-peg had broadened his already squat nose, and this heightened the negroid aspect of his face. But as soon as we were used to this deformity, his face ceased to be ugly, being redeemed by its pleasant smile and brown, twinkling eyes. His hair and beard were as full as those of an unbarbered European, and a fur-like growth covered his chest and arms. The hair itself was long and straight, and its colour had been jet-black, but it was now fast turning grey. Emil spoke English very badly, and he was mentally the most primitive of all our guides. "Missionary

corroboree," as he called it, and the experiences of a journey to Adelaide had affected him very little. He spoke of the southern cities with the same amused interest that he took in us. The things that surprised him most were "the big-fellow whistle" on the steamer at Port Augusta, his seasickness when going down Spencer's Gulf, and the fact that he could get fresh water out of the Murray by the simple process of dropping a bucket into it. His attitude towards things in general was rather that of an average English child, than that of an adult negro; and, unlike the boisterous humour of the negro, his merriment was simple and childlike. Once, for example, he nearly forgot his water-bottle; and when we called his attention to it, he shook with laughter at the idea of his leaving behind that most essential article of his equipment.

Emil was one of the last five survivors of the tribe of the Tirari, a tribe that once lived on the eastern shore of Lake Eyre. He had not been to his own country for years, and we wondered whether he would be distressed by painful memories when visiting the scene of his boyhood. We thought he might have felt like the Last of the Mohicans, grieving over the extinction of his race. But, on the contrary, Emil was as merry as he could be; the only occasion when he showed any sign of grief, at the changed condition of his tribe, was when

he presented me with their sacred, snake-generating stone.

The prettiest feature in Emil's behaviour was his careful attention to Anton, our second guide. Anton was older, sadder, and more civilised than Emil. He was white-haired, short, and bent; his movements were all slow, the result of weakness apparently due to an "attack of sun." Emil seemed to regard it as one of his main duties to ease the way for his weaker comrade, and he took all the hard work on himself. Anton, so long as he could stay with us, was, however, most useful. He spoke English better than Emil, and we always felt we could place more reliance on his statements than on those of his lively guardian. Anton collected fossils with more discretion, though with less zeal than Emil. But he certainly suffered too much to enjoy himself while with us; for the sun made his head ache, and the sand at midday was too hot for his unprotected feet; so he had to go back from Markoni, instead of guiding us round the northern end of Lake Eyre.

Our route from Markoni lay across a plain in a bend of the river. We marched straight toward a big hill, which formed the most striking feature in the landscape, and at first looked like a far-distant mountain. But we soon found that the hill was not so far away as it seemed, and that it was only an especially thick sand-hill, on a high bluff above the Cooper. We crossed the river-bed, and had to climb up the bank on to a sheet of sand of dazzling

whiteness. All the sand we had previously seen was red, yellow, or brown. This white sand covered the bottom of a small basin, which, with its level floor and the glistening salt crystals on its banks, looked like a frozen pool, surrounded by snow-covered slopes. My camel, which was leading, perhaps thought the ground looked too cold for its feet; for it first objected strongly to descend the three feet of bank on to the white sand floor, and then suddenly bolted across it—of course breaking the nose-string of the water camel behind.

After passing the water-hole below the hill at Kuttipirra, we left the last of the timber on the Cooper. Farther west there were but a few scattered box-trees and clumps of needle-bush; but often the largest plant in sight was only a "roly-poly," a spherical bush which rolls over like a ball when driven before the wind. Shortly after dark we reached Patara Mordu, or "the last box-tree," a name which is not literally correct, as we found more box-trees still farther to the west.

Our march next day was to take us to Unduwumpa, a place where we were promised a rich haul of fossil bones. But when we got there, we found that the river-bed was covered deep in sand, and was almost bare of bones. "No catch him there," said Emil sadly, as he looked at the loose white sand which had buried the fossils. I climbed the nearest sand-capped ridge, of which the crest, cut off by the wind, was as sharp as a faceted

stone. The view was fine, overlooking the broad expanse of the Cooper plains and the long, low eastern sky-line, broken only by the Kuttipirra Hill. The slight undulations nearer to me were apparently obliterated by the lack of shadow, under the glare of the overhead sun. To the west I could see more bluffs of the loams; and as it was clear that the fossils were washed from these beds by the river when in flood, we had a good chance of getting fresh material below any of the bluffs. We had a further inducement to search there, for it was nearer the shore of Lake Eyre, which we were all anxious to reach. But we could not go on to the lake-shore without more water; so we had, first of all, to find a fresh supply.

A German, named Eli Hartig, had once raised some cattle a little farther to the west. He had no regular home, having lived in his waggon; but we felt sure there must be a good soakage near the place where he had stayed. We had not seen any trace of his wheel-tracks, so I asked Steer to find out from Emil where Hartig had camped. "What name black-fellow sit down 'long Eli Hartig?" was Steer's first question. But Emil knew nothing about Hartig, or any black who had ever lived with him; and so we resolved to follow the river, and trust to luck to get a soakage.

We pressed on along the river, till Emil took us a short cut across some irregular sand-hillocks, saying, "Cooper walk that way." We were here separated from the Cooper by a line of dunes of

pure white sand; one of them, which we used for some time as a landmark, we called Mont Blanc, as it had a rounded dome, and was of the intense bluish white of newly fallen snow.

Reaching the river, we got some good bones, but saw no sign of water. Emil dug a soakage; it was too salt, as indeed I had expected from the geological position of the place. Anton, however, came up with the joyful news, that he had found a soakage in a low hollow in the dunes, to which he had been led by following a dingo track. We went back there and found it. This must have been Eli Hartig's soakage, for it had been dug out, and the walls had been supported by some box frames. The sand had filled up the old well, but by digging it out we got a fair supply of water. The light thrown on the nature of soakages by those we had dug left me tolerably certain, we should have no serious difficulty with water in this part of our journey.

Soakages are an important factor in travel in the Lake Eyre basin, and their nature is not always correctly understood.

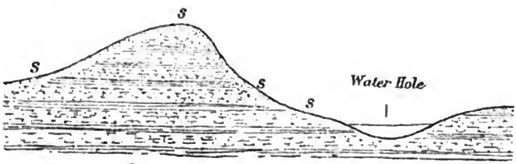
The rainfall in the Lake Eyre country varies in amount up to six inches a year. The rain comes down in heavy showers, and soaks quickly into the sand-hills, where it collects in the layers of sand between the less permeable beds of loam. The water works slowly downward, and discharges at any point, where there is a depression in the surface of the ground below the water-level. The

existence of water-pools in the bed of the Cooper and the Diamantina, in places where there has been no rain or floods for a long time, proves the existence of an accumulation of water in the adjacent ground. Many of these water-holes are only a foot or two in depth, and yet they last through long periods of drought.

The evaporation in the Lake Eyre country, according to the data supplied to me by Sir Charles Tod, is a hundred inches a year. The loss by evaporation is sometimes as much as one inch a day. Taking the average at a hundred inches in a year, a pool one foot in depth would dry up in six weeks. We found shallow pools in places where there had probably been no rain for more than twelve months; and such pools can only have been maintained by the renewal of their water by drainage from the surrounding sand-hills. The pools are generally filled with brine, formed by the concentration of the salt originally dissolved in a great body of water. The brine itself is useless, except that it indicates the existence of water in the adjacent ground; and as this water is stored-up rain, it is fresh, except when it has dissolved salts from the soil.

A soakage is simply a hole dug on one of the lines of drainage into the water-holes. Hence they are usually found on the lower slopes of sand-hills or on the edges of brine pools; and the presence of water can often be traced, by the existence of lines of damp ground or patches of

green rushes. Where the water passes through beds which are saturated with salt, then the soakages are salt; and to get a fresh soakage the hole must be dug above the level of the salt-charged ground. If the salt extend higher than the water-level (as, later on, we found it on the Macumba), then there is no reasonable chance of getting fresh water; and search must be made for an area, where the water-level rises above the salt-level.



SECTION ACROSS A TYPICAL SOAKAGE.

The general geological character of the soakages is explained by the accompanying diagram. It shows a hill composed of alternate layers of sand and loam; it is capped by a ridge of sand, and has a thin layer of sand down both flanks (*s*); rain has soaked into the hill, and, as usual, the water in the ground roughly corresponds with the surface of the ground above it. Thus the water-level is highest below the crest of the hill, and slopes downward on either side below the plains. The river has cut its channel below the water-level, and its bed below that line is filled by drainage from the hill, and maintains a constant supply in the water-hole. By digging

beside the water-hole, the water percolating into the pool is intercepted, and the soakage yields a supply of water that is fresh.

The Mound-Springs, such as those near Hergott, Blanchewater, and elsewhere along the south-western edge of the Lake Eyre basin, are quite distinct in their origin. Their water is not local surface water derived from rain. It is of deep-seated origin, and works its way to the surface along fissures, where the Lake Eyre rocks abut against the older rocks of the Peak and Hergott Ranges. As these waters come from great depths, they are hot, and they contain abundant minerals in solution. This material they deposit in a mound around the spring. As the water keeps its channel clear, a crater-like cup forms in the centre of the mound; and altogether the hill has a considerable resemblance in shape to a volcano. The mound-springs were originally described as volcanic by the earlier travellers, such as F. G. Waterhouse.[1] But the material of the mound appears to be mainly due to precipitation, and is not of volcanic origin.

Watering the camels at Eli Hartig's soakage[2]

[1] "Report by Mr. F. G. Waterhouse on the Fauna and Flora, Natural History, and Physical Features of Australia, on the Line of J. McD. Stuart's Route across that Continent from the South to the North Coast" (Parl. Pap., South Australia, 1863, No. 125, p. 3).

[2] The position of the soakage is 250 yards in a course bearing 218 degrees from a box-tree below a conspicuous dune on the left bank of the river. It also bears 239 degrees to a prominent sand-bluff at the southernmost point of the curve at Unduwumpa. Bearings magnetic.

took longer than we expected, and it was after six o'clock in the evening when we resumed our march.

We followed the Cooper to the north, with a long line of bluffs on our left and a ridge of lower white sand-hills to our right. This white sand only occurs along the river-bed and in the dunes formed upon it. Its dazzling whiteness is no doubt due to the fact that the river water is sometimes rich in alkalies; and these alkalies dissolve the iron salts, that colour the sand of the plateau red, or yellow.

As we approached a bend in the river, the right bank rose into steep bluffs, and the low flood-plain lay on the opposite side. We crossed this plain till it ended at the foot of some high cliffs, built up of horizontal layers of loam and clay and beds white with crystals of gypsum. We climbed on to the plateau, which on its eastern edge was cut up by a series of deep gullies, producing scenery of what, in America, is called the "badland" type. The surface here was bare of soil, and the underlying clays were cracked by the heat into hexagonal blocks, like the pavement of the Giant's Causeway. The plateau was singularly desolate; the vegetation consisted only of an occasional needle-bush tree, and, on an average, there was a small, dried herb and two tufts of dead grass to every three square yards of the ground. Night was falling fast; and as we crossed the first line of sand-dunes on the plateau,

there was just light enough to show that the weather looked as wild as the scenery. Steer deplored the fact, that the wind had not been in the right direction for rain at that season of the year. As he explained, the Lake Eyre country has no rain of its own,—in winter it catches a few southern clouds that have straggled northward; in summer it gets a few tropical storms that have lost their way, and got to the south of their usual course. So he predicted that we should get no storm, as the wind had been from the wrong quarter. But the clouds, at our last view of them, looked so mischievous that we considered the advisability of camping at once.

Emil, perhaps from force of habits acquired in old days, when he did not travel in company with a water-cask, wanted to camp near the creek. He tried to lure us on by the promise of a soakage.

"Bah! No catch 'im soakage 'long this one sand-hill!" replied Steer. But on the positive promise from Emil that the creek was only a "piccaninny long way" we went on. Striking matches, I saw that, though we were descending slightly, my aneroid was falling fast; so we urged the guides and camels to hasten forward.

The wind had been from the north; but it was now a dead calm. The sky was of ominous and pitchy blackness; and the silence was unearthly, even for the desert. We could hear nothing but the dull blows of the camels' feet

on the hard sand, and the occasional creek of a shifting load, or the clank of a hobble-chain.

The absolute stillness was at length broken by a few gentle puffs of wind from the south-west. We were at the head of a gully, which, the guides said, led from the plateau to the riverside, and we hoped to get down into shelter. But we heard a shrill cry coming across the plateau; the sound changed to a whistle, which deepened into a roar, and the storm in all its fury was upon us. The wind struck us such heavy blows that we could hardly stand against it, and I feared the camels would be thrown off their feet. The noise was deafening. We could not make one another hear, even by shouting. Instinctively we all rushed to unload the camels and closely hobble them.

We could not see three yards ahead, and the wind hustled round us from such varying directions and with such varying force that, had we wandered ten yards from the line of loads, we could not have found our way back, except by accident.

After fastening the camels, we could do nothing but crouch behind the saddles, covering our heads with our blankets. For an hour and a half we were bombarded by coarse grit; then came a lull, of which we took advantage to make sure that the camels were not getting into mischief. Emil was crying for Anton, who had got separated from the rest of us. We shouted together, and he heard us; and we found that, though he had been unable to find his way back to us, he had only been a few

yards away. The storm again increased in violence, and most of us withdrew to our shelters. Lyons, however, defied the elements, lighted a fire and boiled some tea. I thought the proceeding Quixotic, but I gladly drank my share. After eleven the storm abated, and we had a cool, refreshing night.

Our collecting-ground next morning was the richest we found during the expedition, and fully compensated us for our disturbed night. We made a covered pile of the bones collected, and pushed on westward. The heat was intense, and our efforts to find fresh water were at first in vain, as the soakages we dug proved salt. In the afternoon we fortunately found a slow, fresh-water soakage at Waralamanko. Anton had not recovered from his buffeting by the dust-storm, and was suffering from "too much walk about," as he called it. We therefore left him to open up the soakage, and collect a store of water for use on our return. There were several dingo tracks about this soakage, so we teased Emil about his sporting yarns, until he started off to try to prove the possibility of their truth. The simple method of hunting, which he described to us, seemed too much like the proverbial pinch-of-salt system for us to accept it without evidence. Emil assured us that he catches turkey-buzzards by sitting beside their nest till the birds come back to roost, and that he kills dingoes by crouching beside their dens and seizing one by the hind leg as it comes out. Emil's main regret, when we parted from him, was that

the country was so desolate, that he had not been able to catch either a single dingo or buzzard, to demonstrate his skill at this game of sporting patience.

On this occasion he soon came back, saying "No catch 'im dingo," so we continued our journey down the river. In the west we could see a line of comparatively high land, from which we felt sure that we should get a view of Lake Eyre. We reached the delta of the Cooper, and camped at sunset on the high plain between the river and the lake. I made a hasty walk to the west, and became certain that we were only a few miles from Lake Eyre. At dawn next day Dow, Donaldson, Lyons, and I walked over the plateau, crossing a lake-bed and a series of parallel sand-dunes, and reached the shore of Lake Eyre.

So far as we could see there was no water in the lake, though a damp feeling in the air that blew over it suggested, that some parts of the lake-bed were at least wet. Our guide, Emil, said that he could see water away to the north-west; but though our eyesight, for long distances, was as good as his, we could not confirm this statement. We could not see very far, however, for the day was dull, with a low haze on the lake-plain and thick clouds over the whole sky. Where Emil pointed to the water the clouds were particularly dark and lowering, and the lake-bed was a heavy leaden grey; but not even with the telescope could we detect any sign of water. Some miles to the south-west

THE SHORE OF LAKE EYRE.

we could see in the lake some "islands," if we may use that term for a hill surrounded by land.

The lake, the native name of which Emil said was Kati-tanda, was also dry when seen by Lewis and Warburton, both of whom were much impressed by its singular melancholy. "Lake Eyre," said Warburton,[1] "was dry—terrible in its death-like stillness and the vast expanse of its unbroken sterility. The weary wanderer, who, when in want of water, should unexpectedly reach its shores, might turn away with a shudder from a scene which shut out all hope—he could hide his head in the sand-hills, and meet his fate with calmness and resignation; but to set his foot on Lake Eyre would be like cutting himself off from the common lot of human beings. I had a cheerful companion, a good horse, and some tea and damper; but I felt a dismal fascination in looking on this lake, hardly knowing whether I saw before me earth, water, or sky; and I could not help thinking what might have been my feelings had my circumstances been less happy than they were."

Lewis's opinion of the lake was also unfavourable. On finishing his survey of the eastern shore he exclaims with relief,[2] "I sincerely trust I may never see it [Lake Eyre] again. It is useless in every respect, and the very sight of it creates thirst in man and beast. To read over my account of

[1] Warburton's Diary of Explorations in the Northern Portion of the Province in 1866 (Parl. Pap., South Australia, 1866, No. 177, p. 6).

[2] Lewis's Journal of Lake Eyre Expedition (Parl. Pap., South Australia, 1875, No. 19, p. 32.

my travels on it will convey to the reader a very scanty knowledge of the hardships and uninteresting work we had in mapping the shore. I had instructions to level the head of the lake. . . . I was also instructed that if the lake contained water to make a boat and sound it. This was not necessary, as all the water we saw was under the surface. We were out on it for two or three miles in several places and examined it with powerful glasses, and also from the top of the highest sand-hills, and never saw a drop of water. It is my opinion that Lake Eyre is dry (as far as concerning surface water) north of the 29th parallel of south latitude."

We made a short cruise out over the lake, and could have gone much farther; but the journey would have been unprofitable, for there were no fossils on the lake-bed, and our camels were in need of water. So we hastened back to them, and took them to the soakage, where Anton had meanwhile collected a fair supply of water. Then travelling more slowly, collecting as we went, we returned up the Cooper. We made several variations from our outward route, during one of which Emil was uncertain as to the best way across the dunes. "What! bushed again?" we said to him; and, to his great amusement, we condoled with him as to the shortness of his memory for places. We suggested to him as an excuse that, until you are used to them, one sand-hill is exactly like another—a view of sand-hill scenery which never seemed to have occurred to him before. Later the

same day Emil suddenly turned off the line of march, and we could see he was tracking something. He started digging on a small hummock with his stick; as he loosened the soil with one hand he threw it out in great clouds with the other. Steer was in a hurry to go on, so he vainly tried to goad Emil into abandoning this hunt.

"There is nothing here," said Steer.

"Him sit down all right," said Emil with absolute confidence, as he continued his furious digging. He was too intent on his work to notice any further sarcasm, until Steer remarked, "Him sulky now," at which idea Emil stopped for one short bark of contempt; as he did again when urged to stop digging, as Steer complained that he was making his shirt dirty. The hillock was the home of an adult, but pygmy bandicoot, which Emil soon unearthed, and handed over to Dow to add to our scanty store of mammals' skins (see Appendix II., p. 354).

On the way back we halted for our last midday rest at the foot of Kuttipirra. The heat was unusually severe. Emil described it as "big-fellow hot," and I found the ascent of the hill at 2 p.m. uncomfortable. The hill was crescentic and capped by dunes, with a steep northern face. The summit commanded a fine view over the broad, flat-floored trench of the Cooper, with its sinuous line of brine-pools glistening in the sunlight. But now my main interest was in the land to the north, which

separated the valleys of the Cooper and the Diamantina. The country in that direction seemed level and traversed by long parallel sand-dunes; they were so regular and so numerous that, when crowded by foreshortening in the distance, it looked as if the whole country had been ploughed into a series of furrows. The alternate lines of the sand-hills and the dark brown strips of loam gave a singular streakiness to the view.

One more march took us to our base camp at Markoni. There we found that our companions, Grayson and Guy and Voss Smith, had made a good collection of fossils and zoological specimens, our inspection of which was interrupted by a severe dust-storm. Markoni also had been troubled by the night dust-storm, which had damaged the tent, and had nearly buried the men by piling sand several feet thick above them.

As the meteorological conditions indicated that the storm would be followed by some days of cool weather and south wind, I resolved to forgo a projected day's rest in camp, and to start off next morning on the march across the Tirari Desert, over fifty miles of waterless sand-hill country between the Cooper and the Diamantina. We therefore sent back all the Kilalpaninna natives, except Jerry and David, the two Wonkonguru guides. Here occurred an incident which shows that the Australian aborigines are better than they are often said to be. We were using tea and sugar at a greater rate than I had allowed for,

The brackishness of the water drove most of us to take sugar with our tea; and we drank tea by the quart. We all agreed that tea was the one article that was absolutely necessary to our comfort, and that we could understand any one, whose tea had given out, believing the worst that has ever been written about the Australian desert. So, on serving their food rations to the aborigines, who were going back to Kilalpaninna, I expressed regret, that we could only spare them a scanty allowance of tea and sugar. Their spokesman at once, after consulting the others, came back to say that they were returning to the station and could get anything they wanted there, but that we had a long journey before us and no chance of getting fresh stores; so that they would prefer to return the tea and sugar we had given them. It was, fortunately, unnecessary to accept this offer; but the incident well illustrates the generous disposition of the Australian aborigines.

CHAPTER VII

ACROSS THE TIRARI DESERT

No sweet fall of rain
May there be heard, nor sweeter liquid laps
Of rivers, o'er the pebbles gliding by
In murmurs; goaded by the rage of thirst . . .

DYER.

THE march from Cooper's Creek to the Diamantina, at the season when we had to make it, was expected to prove a difficult journey. We had to go for fifty miles over waterless country, covered with lines of sand-hills, and it was uncertain whether we should find any fresh water at the end. After our experience of soakages in the Cooper Valley, I had, however, no doubt that we should get as much water as we wanted at Kalamurina—the old station where we expected to reach the Diamantina. This faith in the existence of water ahead of us made a great difference to the comfort of our march, as it rendered it unnecessary to have a large store of water in reserve on our arrival at the river.

We struck camp at Markoni on January 4th, 1902, and returned on our former track to a big soakage on the banks of the Cooper at Ilturini.

RETURN FROM LAKE EYRE. DELTA OF COOPER'S CREEK BELOW OUR LOWEST CAMP.

TIRARI DESERT, LOOKING NORTHWARDS TOWARDS THE DIAMANTINA.

There we gave the camels as much water as they could drink, saw that our casks and water-bags were as full as they would hold, and after lunch started on our desert march. We kept along the Cooper for a couple of miles, until the river swung back towards the south-east. We then left it and struck across country to the north-east. For the first few miles the landscape was very dreary. The surface was undulating and crossed by narrow sand-hills, which ran in parallel lines from north-north-east to south-south-west. The dunes were small, varying from six to twenty feet in height; but they were so numerous that the country, from the highest point on the ridges, looked as if it had been furrowed by a mighty plough. The vegetation consisted mainly of a few dark green "needle-bushes"—low trees which have somewhat the form of the mallee, but are smaller and have more slender stems. A needle-bush to every two or three square miles, and a tuft of dead cane-grass and a dead "wild carrot" to every five square yards, was a fair measure of the distribution of the vegetation. The crossing of a wire fence reminded us that the country had once been occupied; the fence was broken and dilapidated, and in places covered by sand-drift. My attention was first called to it by nearly tripping over it, as I was walking quickly some distance behind the caravan. The fence looked a sad mockery, separating a district where there were no people, from an area where no one would want to go.

Our course, at first, was oblique to the trend of the sand-ridges, and we had to cross many of them before we struck the Kalamurina Road. This was not much of a road, merely a cattle-pad, so faint that the guides were doubtful whether it was the right trail. But we followed it on trust, and after a time we found some dray-tracks. The country became better for camels, and afforded the easiest travelling we had during our journey. The ground was a firm clay, and the surface smooth and stoneless; the route was straight; the gradients were easy. As the wind was behind us and the weather cool, we made three miles an hour, with less trouble than we sometimes had when going at half that pace. About sunset, we crossed an arm of the bare bed of a large lake—Punta Wolona. The lake was waterless, but its bed had a billowy aspect, for streaks of dark brown, along the damp ground, alternated with slight ridges, which, being dusted with scattered sand, looked like rows of spindrift.

While crossing the middle of the Tirari Desert, we had little to observe and less to collect; so we had a respite from our work, and could lazily enjoy the journey. The country, seen through the black spectacles which we generally wore, looked not unpleasing. We were more used to this type of country than when we had suddenly entered it, upon leaving the comparatively fertile margins of the water-holes of Cooper's

Creek. The landscape consisted of brown ridges, capped by light, yellow lines of sand, running out in long, low wedges; and the level valley-floors were dark with dead cotton-bush and acacia. The fact that the native vegetation—especially modified, as it is, to resist long periods of drought—was all dead, gave striking evidence of the severity of the climate during the past years; but with a return of better seasons this country would rally more quickly than the plains along the Queensland Road, for here the grass-tufts and bushes have not been eaten off. There was never any inducement to take up this country, since there is no water on it, except after rain, when the stock could be fed elsewhere. The rabbits too seem rarely to have reached it; for though the ground a couple of miles back from the Cooper was littered with their bones, we found few traces of them here. But as we continued our march, the aspect of the country became more dreary and forbidding, and the heavy clouds deprived us of the cheering sunlight. Day after day, while we were in the Lake Eyre basin, the whole sky was too overcast and the light too dull for us to take satisfactory photographs; and it is only in bright sunshine, that the attractive features of desert countries are apparent.

During this part of our journey, I often loitered behind the caravan, walking along the top of the sand-hills to get a wider view across the country. The soil was bare, the grass-tufts

withered, and the scenery seen from the dune-crest was undeniably depressing, and the whole land looked dead. The few black, stunted trees, with their gnarled trunks and leafless or needle-leafed boughs, had an appropriate resemblance to dead, funereal cypress. The sides of the dune were covered by long, wavy sand-ripples, where the wind had driven the grains up the western slope; but at that time not a sand-grain was moving, and the ripples looked as motionless as the fossil ripple-marks, that may be seen on some London paving-stones. The air was still and heavy—there was not a sound; and the only visible sign of life and motion was the steady drift of the useless clouds across the leaden sky. Earth and sky seemed to be out-vying each other in repellent monotony. The earth was repulsive in its arid, forlorn barrenness, and the sky was still more repulsive in its sunless pall of cloud. The contrast between these rich plains, wasted by drought, and the sky, depressing from its wasted cloud, was pathetic. If only the clouds, which day after day threw a dismal gloom over the sunless plains, would drop one tithe of their contents, how the long-rested soil would riot with vegetation!

The most urgent need in Central Australia is to tap the vast store of water, that now floats in contemptuous irony some thousands of feet too high. How high the clouds were above us, and how thick, I could not tell. I longed for

a Hargreave's kite to send up into them, with a meteorograph to record their height and thickness, and the extent of their store of water. Sometimes the clouds seemed to come quite low, as if to tease us—goading one into speculations, how to prevent their escape again into the upper air. Reduce the temperature of these clouds a few degrees, and their moisture must be condensed and fall as rain. And I dreamed of sending up box-kites, which should spray these sullen clouds with liquid air, and precipitate their wasted moisture on to the waiting plains below.

On the third day of our march, as we approached the Diamantina, the vegetation looked better, though the dull, grey clouds still gave the country a gloomy aspect. We actually had a few drops of rain, just as we started on our march; it was a light shower, which lasted for less than a quarter of an hour, and did not thoroughly wet the ground; a change in the vegetation indicated that we had entered a region, where rain and dew were more abundant than farther south. The scenery became a study in green and grey, instead of in brown and yellow. The needle-bush was dark green, the cane-grass a light yellowish green; and in the dull light the distant tints repeated the heavy, monotonous grey of the sky. Away on our left we saw a long, level line, which appeared to be a lake-bed; and as we approached it, we

found that it was the broad, clay-flat of Lake Kalkutinna.

Later on, another vast lake-bed appeared up on our right. Jerry, the Wonkonguru guide whom we had taken instead of Anton, told us it was Lake Tanikuna, which reached northward to the Diamantina Valley. The valleys here became broader, and the hill-lines more regular and distinct. We marched for some distance over a band of smooth level ground, between two curved ridges, as regularly concentric as if they had been artificial earthworks beside a race-course.

In the afternoon we first saw, far to the north, a line of grey dunes, which we guessed must be the hills beyond the Diamantina. They were faced, here and there, by bright white patches, which, as we approached, proved to be the ends of the sand-capped ridges, cut across by the river-valley. Between us and the bluffs of the northern river-bank, lay the broad, dark timber-belt on the flood-plain of the Diamantina. We descended the southern bank of the valley to a broad, bare clay-pan, and, finding an old cattle-trail, followed it to a group of sand-dunes. We crossed a gap in them, and below us, nestling in a cup-like hollow of the dunes, lay the deserted station of Kalamurina.

It had been abandoned by its first owners some years before; but we had been told at Kilalpaninna that it might still be occupied by a

stockowner named Tom Naylon, and that probably some aborigines would be camped beside it. We hoped to learn from them the present condition of the country along the Diamantina, and possibly get a stock of fresh meat from Naylon. We were disappointed to find the station completely deserted; for it not only meant we had to find our way without recent information as to the condition of the water-holes, but it was symptomatic of the severity of the drought by which the country was stricken. There was, however, an abundant water-supply in a large, freshwater pool in the bed of the Diamantina; and I felt assured, from conclusions as to the general geology of soakages, that if the hills on the Lower Diamantina were as large as they were represented, then we should get plenty of water from them. The hills might cause great delay in crossing them, and they might even be impassable to our camel caravan; but, in that case, I knew they would give us sufficient water. So, instead of sending on a party to form a water-depôt at Poonaranni, as I had thought might be necessary, we settled down to study the natural history of this part of the Diamantina Valley.

CHAPTER VIII

THROUGH THE VALLEY OF THE DIAMANTINA

Where the Warrigal[1] whimpers and bays through the dust of the sere river-courses.

KIPLING.

KALAMURINA—the "place of rushes"—was reported to be rich in the remains of Kadimakara. We had been told that there was a stockyard on the station, with walls made from the bones of extinct monsters. So we expected to find a large collection of fossil treasures there. A flood had, however, come down from Queensland eight months before, and covered the bone-beds in the river with a layer of silt. The bone-built stockyard appeared to be a myth.

Kalamurina was therefore a disappointment as a locality for fossil bones; but it was the best zoological and botanical collecting-ground we had yet visited. It was necessary to examine the geology of the country for some distance eastward along the Diamantina; so Grayson, Voss Smith, and I started off on this excursion, with David, the Wonkonguru, as our guide. The

[1] The Dingo.

others remained at Kalamurina to work that productive field.

We started at 8 a.m. on January 8th. The day was unusually hot, for the thermometer marked eighty-six degrees in the shade as we left the camp. The sky clouded over during the morning, so that the atmosphere felt close and oppressive. It was one of those trying days, when, as Herr Reuther expressed it, "the sky was not clean." Our road lay first across the white sand-dunes at the back of the station, and then over the broad clay-pan of Lake Kalamurina to the foot of the high ridge of Murreebirrie. We found that this hill had the same structure as most of the so-called "sand-hills" in this country. Instead of being composed of sand, it was made of loam, had a thin crust of white sand on each slope, and was capped by a low sand-dune along the crest.

When we reached the trigonometrical signal on the summit, a fine view burst upon us. A broad plain extended as far east as we could see; a series of parallel wave-like ridges, each crested, as by a breaker, with a long white line of sand, ran from north to south across the country. The hollows between the ridges were tinted dark brown by dead lignum-bushes; but a few patches of green showed that some showers had recently passed over the country. The sand-crested ridges ran as far to the south as we could see; but to the north they were sharply cut off by the valley of the Diamantina, which meanders across a level

flood-plain, some two or three miles in width. The river-flats were dark green with scrub and low trees; and beyond this "timber-belt" rose high bluffs of yellow loam, forming the face of the plateau on the northern bank of the river. Here and there a talus bank of snow-white sand lay against the yellow face of the plateau, which was in places surmounted by patches of buff sand, where the long ridges were cut across by the river-valley.

The view was extensive and full of interest. In this land of reported uniformity we had found another type of scenery, different from those of the stony plains, the Desert Sandstone hills, the flood-plain of the Cooper, and the channel of the Lower Cooper. The conditions here were most allied to those of the Cooper near its delta; but the scenery was on a grander scale, owing to the greater size of the Diamantina, its deeper valley, its larger tributaries, and its richer timber. We halted for a short time to take in the principal points in the view, and then began a steep descent to the east, keeping most of the way along a spur in order to ease the camels. After reaching the plains we found a cart-track, and followed it eastward, skirting the timber-belt, and keeping on the edge of the loam-hills. The boundary was remarkably sharp between the mud-flats reached by the flood and the hard, sun-baked loams above that level. It reminded me of Dr. Howitt's description of the Diamantina Valley,

Cliffs of the Diamantina, West of Kalamurina, with a Water-hole in the Bed of the River.

when he reached it farther to the east, after a heavy flood, during his expedition in search of Burke and Wills. The boundary between the dry and the flooded area was then so sharp, that Howitt's horse stood with his fore-legs up to the withers in grass, while its hind-feet were on the bare, desert loams.

The physical causes of the present condition of this part of the Diamantina are the great volume of the river when in flood, and the heavy load of silt that it brings down from the Queensland hills. When the speed of the river slackens, as it spreads over the timber-covered plains, it deposits its load of mud, whereby its bed is raised and its bank thickened. The small tributaries, that trickle down from the plateau after showers in the desert, are unable to cut their way through these deposits to join the main river; they, therefore, spread out into swamps or lakes, from which their waters are removed by evaporation. Accordingly, at the lower end of each valley from the desert plateau, there is a clay-pan, which is occasionally flooded from the higher ground. We crossed several of the wide clay-pans, of which the last and the largest was brightened by belts of golden yellow, due to lines of dead grass-tufts. We then entered the timber-belt, and reached a crescent-shaped hollow with a rich growth of rushes on the floor. I thought, at first, that this was the main river-channel; but it closed suddenly at both ends. It was a billabong, a now isolated

water-hole, which had once been part of the main channel of the Diamantina. David told us that this was the water-hole of Wadlakanninna; and as the river here bends abruptly to the north, we struck across the timber-belt to find the main stream.

We passed several billabongs—some of them curved, others horse-shoe shaped—and we searched their beds for fossils; but they yielded nothing except fine river-mud. The timber became thicker as we got nearer the river's edge, and the scenery somewhat reminded me of those parts of the Tana Valley in East Africa, where the scrub is thin. But the Diamantina was less interesting and varied. I missed the palm-trees, the banana plantations, and the villages of beehive-shaped huts; and even the biggest of the box-trees are insignificant in comparison with the great Tana figs. When I noticed the richness of the soil, I could not but think what a paradise this country would be, if it only had an East African rainfall. It is grievous that the floods, when they do come, now run to waste. The desolation of this land is truly deplorable, for it has a healthy climate and a rich soil. It is not plagued by tsetse or malaria, and—at least when we were there—it has few flies and fewer mosquitoes. The short time, during which settlers have occupied this part of Australia, has been practically sufficient to exterminate the native races, without enabling their supplanters permanently to occupy the land. Thus the

country is probably more utterly wasted and deserted at this present time, than it has been at any period since the first human occupation of the district. Civilisation has destroyed the people who could live there, and has not yet been able to secure the settlement of the country by our own race.

David suddenly interrupted my reflections by telling us that we were near the river, and that there were plenty of bones in its bed. So we stopped for lunch on a bluff overlooking a pool alive with pelicans and ducks. Voss Smith went off with a bent gun that we had acquired during our wanderings, while I examined the bone-beds, and Grayson made tea. The river-bed was strewn with bone fragments, among which we found some interesting fossils. The heat in the river-channel was intense, as the high banks kept off every breath of air, and the sun blazed down upon us as we bent forward in our search. With Australian contempt for climate, we worked steadily from half-past one to half-past three, although it was one of the hottest days of the journey. The water in the pool was merely brackish; so we could afford to have a second supply of tea, after which we resumed our journey along the river. Progress was slow, as we made repeated visits to the river-bed to look for likely localities for bones. David was anxious to reach a water-hole some distance ahead of us; and though, no doubt, he could have easily gone straight there on foot, it was not easy to find a

direct route for camels. We stumbled down a bank so steep, that the camels were nearly rolled over by their loads; and we forced our way through scrub, till it became so dark that I refused to let the camels go any farther, for fear that they should lame themselves by treading on spikes of wood. Shortly after our black guide and I had begun preparations for camp, Grayson and Smith came up on their camel. Grayson, for the first time on the journey, was in raptures over the beauty of a water-hole on the river. He stated its attractions as a camping-ground with such eloquence, that we named it Grayson's Paradise. But the charms of the landscape would have been lost upon us in the darkness, and Grayson's and Smith's estimates of the distance were very different. There is an African proverb, that no one who thinks there is a better camping-ground a mile back will ever reach Uganda; and in accordance with that sound maxim we camped where we were.

Early next morning we continued our journey eastward up the river. We passed a conspicuous sand-capped hill named Piacoodna on the northern bank, and reached a point where the Diamantina broke up into several channels, each a broad strip of bare, white sand. We crossed the island between the arms or dry anabranches of the river, till we came to a rocky bar across the channel, at Stony Crossing, or Ulabarinna. Here for the first time we found a layer of hard rocks included

in the loams. Above the rough rocky barrier was a large pool of brackish water. We stopped for some time to collect, as this was to be our turning-point.

David laid a chain of fires as a message to his friends at Cowarie. The fires were so arranged as to send up clouds of smoke at various intervals; but whether this arrangement would tell the people of Cowarie anything more than that the fire was intended as a signal, and was not an accidental bush-fire, I could not make out.

After leaving Ulabarinna we returned down-stream, collecting bones at the places we had noted on our upward journey. Late in the afternoon we were near Grayson's Paradise, so we decided to go there for tea. Smith and Grayson went on ahead to shoot some of the innumerable water-fowl; but when we reached the place it had lost the glamour given it by the twilight. Under the strong glare of the high sun, the water-hole looked little different from the rest of those in the river-bed. Smith's attempts to shoot were unsuccessful, for he got badly bogged in trying to cross the bed of the river; so the place proved a failure as regards sport and scenery. But my companions decided that at any rate they would indulge in the luxury of a bathe. This had to be postponed till after tea, so that I might go on with the pack-camels; for it was necessary to hurry on, to avoid crossing the Murreebirrie ridge in the darkness.

After a hasty meal I started ahead with the baggage-camels; and when I had gone a couple of miles on the road I heard Fireworks chasing after us at a pace, which at first alarmed me. My companions, however, were both safely on the camel. They reported that the Paradise had been a disappointment as a bathing-place; for the treacherous pool consisted of a few inches of water on as many feet of slime. Fireworks became furious at being left behind, so that they had no time to wash off the effects of the first plunge. As soon as they were on the camel, he bolted at such a pace that his riders were severely shaken, the bent gun was jerked on to the ground, and Fireworks could not be persuaded to stop to pick up such a trifle. Nothing would content him, till he had taken up a safe position in the rear of the camel-train.

We reached the track a little before sunset, and it was dark long before we arrived at the eastern foot of Murreebirrie. David, however, offered to guide us round its northern end; but it was soon so dark that we several times lost the track, and we stumbled for a couple of hours through scrub and over sand-hills. At length we saw the light of the camp before us; but, to our disgust, it suddenly went out, for our companions had given up hope of our returning that night, and had just gone to bed. We had to grope our way blindly across the last sand-hills, till we were within hailing distance. Then our noisy shouts roused the

High Cliffs of the Diamantina, West of Kalamurina, showing the Bedded Loams which contain the Bones of the Kadimakara.

sleepers, and their replies guided us to the camp. We were glad to hear that they had made good collections, and were so delighted with Kalamurina that they wished we could stop there for a month at least.

But we had no such time to spare, as we had now only ten days left in which to march round the northern end of Lake Eyre, and catch the fortnightly train from Warrina to Hergott. I calculated that we could do the journey in the time, unless we were seriously delayed in the search for water. Our camel-driver thought the march impossible in the time; but, seeing that we were resolved to try, he loyally did his best.

The first fifty miles of the journey west from Kalamurina lay along the course of the Diamantina. The scenery was full of variety and often beautiful. The river passed below cliffs of marl, crowded with large gypsum crystals, whose faces flashed in the sunlight like plates of silver. Elsewhere the river-channel was bounded by high bluffs of bedded loam; and from their summits we enjoyed fine views of long, serpentine reaches of salt water, entrenched in the broad river-bed. Additional interest was given to these salt-pools by the swarms of birds that frequented them—swans, shags, pelicans, goliah-parrots, and sea-gulls.

The comparatively cool spell of our stay at Kalamurina was now over, and a hot wave was crossing. But as this meant a few days of

cloudless sky and good colour-effects, we were compensated for the loss of comfort by more distant views and brighter scenery. Towards sunset we observed a rare cloud-effect; it consisted of a broad band of coloured light, looking like a short length of a rainbow, but occurring near the sun.[1] Steer said this was a "water-dog," and was a sure sign of rain. But he had never seen one before, so that his generalisation was based on too short a series of cases to be reliable.

The same night we had a mishap, which led to an unfortunate delay next day. We had not watered the camels that day, and one of them, during the night, tempted by the moist odour of the brine, ventured into a water-hole on the river-bed and got badly bogged. When the camel was found in the morning it was over its withers in mud, and the mud had set, owing to the weight of the camel; so that its legs were held as tightly as in a block of plaster. We cut down a great quantity of brushwood and faggots, and strewed them on the mud to form a platform round the camel; then we dug a deep trough along one side

[1] The sun was eight degrees above the skyline, and had just sunk below a dark bank of nimbus, with bars of stratus clouds across it. From the edge of this bank rose a blunt projection of nimbo-stratus cloud, occurring at about fifteen degrees from the sun and on the same level above the horizon. Five degrees farther from the sun was a vertical band, consisting, in order away from the sun, of red, yellow, green, and blue bars. The colour-band was twice as high as wide, and was closed above against the straight lower edge of a bank of cumulo-stratus cloud. The colour-band was clearly due to an invisible column of vapour acting as a prism between us and the sun, of which the direct rays were cut off by the lower cloud-bank.

of it, and packed the mud on the bottom of the trough with faggots until we had a firm shelf. Next we tied ropes to the camel, and, after loosening its other side and digging holes round its legs, we succeeded, by our utmost exertions, in rolling the bogged animal on to the faggot shelf. We held it there while we packed the other side with brushwood. After three hours' hard work we got the animal free from its muddy matrix, and it was able to walk out on our faggot path. We were glad to have got it out without a more serious loss of time. For a time it looked as if we should have had to dig a deep pit near the camel and drain the mud-bed below it. We were fortunate to have got it out safely, for Mr. Helling had written to warn us, that the previous camel-caravan had lost seven camels in a journey down the Diamantina.

From this camp we had to climb over a high ridge, as the southern hills came down to the left bank of the river. The ridge was flat above, and surrounded by parallel rows of sand-dunes. The second row showed us a fresh instance of the infinite variety of dune scenery. On the eastern side of this dune there was a series of three cliffs, so steep that they were quite bare of vegetation or soil, and the white sand on their faces glistened like silver crescents, between the greenish yellow of the rest of the dune-slopes and the loam-plains to the east.

Crossing one of these steep dunes we had another

time-consuming mishap. In descending a steep sand-hill one of the camels stumbled, and his load, saddle and all, fell forward over his head. One of the saddle-horns was broken, and we replaced it with our only spare horn. As ill-luck would have it, the same mishap happened to the same camel later in the day, when the other saddle-horn was broken. Grayson and Steer successfully mended one of the broken horns; but it was not safe to load the saddle with its full burden, so we abandoned some kit that had by then become superfluous. We had travelled the rest of the way so easily, that we nicknamed this unlucky day "our day of disaster."

Next day we made fair progress, and reached the old horse-station of Poonaranni. We had a heavy dust-storm in the afternoon, but we were lucky in escaping the worst of it. The day had been intensely hot, the culmination of our hot spell; and we expected that it would end in a storm, followed by a few days of cooler weather. In the afternoon we were not surprised to see dense clouds rising to the south-west from the bed of Lake Eyre. The wind had been a gentle drift from the north-east and north; but about 3.20, after some minutes of dead calm, we felt a few puffs of air from the south-west. This wind soon increased to a strong breeze, and then to a gale. The air above the skyline was a dark yellow, like a smoke-stained fog, cut off above by a black rain-cloud. Rising from the fog we saw three tall columns of dust,

Digging Out a "Bogged" Camel beside a Water-hole in the Bed of the Lower Diamantina.

which were travelling straight toward us. We urged the camels forward, hoping to reach shelter before the storm struck us; but it was advancing more quickly than we thought, and it caught us on the open plain. As we saw the squall, with its vanguard of light dust charging at us, we changed our direction to meet it, for we feared the loads might be blown over if the squall struck us "broadside on." The hill to the south of us had been covered by a yellow dust-haze, and it was now blotted from our view by whirling fog, through which we could not see for more than two hundred yards. To our right, half a mile away, was the timber-belt by the river; the trees had been alive with thousands of white cockatoos, but they had fled screaming down the river as the storm approached. The heavy wind struck the timber-belt with a crash, and then blew a wild whistle through the branches, till the main blow of the storm drowned the whistling in the groaning and cracking of the trees.

The storm was preceded by a narrow fringe of rain. The drops were few and heavy, but they fell with stinging force. The shower lasted about a minute, and only a dozen drops fell on my face or hands. It was followed by the dust, travelling chiefly in two whirlwinds, which swept past us some three hundred yards away on either hand. By sheer good luck, we had taken up our station in the gap left between the two columns of dust. The storm was short; it only delayed us for ten

minutes, and then we continued our journey to the old horse-station of Poonaranni, where we expected to find an aboriginal camp and fresh guides.

The station stood on a picturesque hill, looking over a water-hole in a bend of the river, which has been deserted owing to a change in its course. The house, with two rooms and a forge, was in fair repair, and the branding-irons were in their places—a striking testimony to the honesty of the aborigines.

To our disappointment there was no sign of the promised camp, and we had still to trust to our Kilalpaninna guides. Their knowledge of the country we were approaching was very limited, as they belonged to the Wonkonguru tribe, living along the Diamantina, between Cowarie and Kalamurina. They assured me that in another day's march down the Diamantina we should find a large pool of fresh water, and also a camp of North Eyre aborigines. But from the increasing salinity of the soil I had my doubts about the fresh water; so we filled our water-barrels with brackish water from the pools at Poonaranni, and prepared for an early start next day. The weather was still hot[1]; for though the wind was coming from the south, it was only carrying back the heated air

[1] The temperature recorded that day at the nearest official meteorological station, at Williams Creek, was 116·5°, and is above the maximum recorded in the years, including every third year since 1892, of which Sir Charles Tod has kindly given me a copy of the official records.

that had been blown there from the north during the preceding week. It was not until 8 p.m., five hours after the storm, that the temperature began to fall appreciably. Then it fell quickly, and we had a cool, refreshing night.

CHAPTER IX

FROM POONARANNI TO THE PEAK

This vault which glows immense with light
Is the inn where he lodges for a night.

EMERSON.

POONARANNI was the last outpost of the stations along the Queensland Road, on the eastern side of Lake Eyre. Henceforth we had to find our way across trackless wilds, till we reached the country visited by the cattle from the stations along the Overland Route on the west of the lake. As we had no precise information about the distances ahead of us, we hoped to make an early start. But the camels, refreshed by a cold night and unlimited drink, had wandered far afield in search of food ; and as the wind had hidden their tracks with sand, the guides had much trouble in finding them.

The camels were not brought in till seven o'clock, and it was a quarter-past eight before the last load was packed and the march begun. We crossed the Diamantina, stopping a few minutes to fill up our water-bags from a soakage in the bed of the river, and then we struck north-westward

on to the plateau. We were now on a great island that forms part of the delta of the Diamantina. For the Kallakoopah River, that lay some miles to the north of us, is really a branch of the Diamantina, which it leaves twenty-four miles north of Cowarie, and rejoins about twelve miles above their joint entrance to Lake Eyre. The delta, where we crossed it, is formed entirely of the estuarine loams, capped by sand-hills. During the ascent on to the plateau Dow found some Diprotodon bones, showing that they are widely scattered through the estuarine series, and are not confined to the lower beds exposed on the river-level.

We had been warned that beyond Poonaranni was a land of big sand-hills, which the camels might not be able to climb. So it was with some trepidation, that we bent our course westward to tackle these dunes. We crossed the first two, however, without difficulty; but after marching over a broad level flat of dry clay, we came to a high ridge which was too steep for the caravan. Steer led the camels across a gap a mile to the south, while I followed the guides to the highest point on the ridge. Thence we saw, to our relief, that we had another piece of easy marching ahead of us, for the ridge sloped gently down to the level flood-plain of the Diamantina. The river flowed through a meandering channel, marked out by a series of long reaches of salt water on the floor of a deep, curved trench. A couple of miles down-stream, a bend in this trench brought the river against

the foot of some high bluffs. The river-bed was too soft and the hills too steep for the camels; so the caravan was driven some distance northward to a saddle across the ridge. I kept along the cliffs, and was rewarded by a view of the most beautiful river scenery we had yet seen. A noble reach of greenish salt water sweeps through a green alluvial plain, against the foot of some high cliffs of yellow bedded loams. Some small gullies run from the hills over the cliffs, and end in prettily timbered hollows along the river-side. The ridge-summits are crested by white sand-dunes, dotted with umbrella-shaped needle-bushes and gnarled, irregularly branched fiddle-trees. A broad alluvial flat extends along the river. Most of it is dark with timber, and it is broken here and there by the sheen of a wind-rippled salt-pool.

The place was alive with water-fowl, shag, and ducks. A few black swans were resting on the pool, and some sea-gulls were lazily flying along it. Lyons made several additions to our bird collections, while Dow tried to get one of the swans. The bird prudently kept at a safe distance; but Dow was rewarded for his walk along the river-muds, by finding an exceptionally well-preserved vertebra of a Diprotodon.

After rejoining the camels, we had lunch under the least shadeless trees we could find, and then started southward, in search of a reported fresh-water pool and camp of blacks at Oanna, a locality ten miles west of Poonaranni. It was important

to get into friendly relations with the aborigines, as I wanted one of them to guide us across to the Macumba. So I sent George, one of our two aboriginal guides, ahead of the caravan to find them.

The guide, after much "cooee," got into communication with the black-fellows, and fortunately learnt from them the position of the fresh-water pool before they had seen any of us. On our appearance the natives fled at once, driving their dogs before them. We found the pool; but wild horses had drunk all the fresh water, and the river water was so salt that the camels would have none of it. We led them to the river, but after one sip they jerked their heads defiantly upward, as if to say, You can take your camel to the water, but you can only make him drink once. When we should next find water was quite uncertain, and we had heard alarming accounts of the sand-hills that lay before us. It was therefore necessary, in order to be prepared for a long and slow march, to give our camels a full drink before starting, and take on at least fifty gallons of fresh water for ourselves. After some search we found a soakage on a sandspit, which, after a few hours' work, yielded us an adequate supply of fair water. We gave each camel a drink of fifteen gallons, and filled up every cask, water-bag, and water-holding vessel we could find.

Next morning we started to tackle the "big-fellow" sand-hills that lay to the west of us. That day's march was the most arduous, but the most

satisfactory, of the expedition. The country was not as bad as it had been painted. The direct road had been represented as perhaps practicable for stock, but impossible for camels, except perhaps, by a circuitous track to the south. Lewis had referred to the sand-hills here as being more like "sand mountains"; and he states that, on the northern side of the lake, "the sand-hills were perfectly perpendicular; nothing short of a wallaby could ascend or descend them."[1]

A hill of sand with perpendicular sides is a physical impossibility; but Lewis's description at least supported the view that the sand-hills were too steep for camels. Probably, however, Lewis may have been referring to hills that were not true sand-hills, but loam-hills, which sometimes have quite vertical cliffs.

The guides were unable to find a cattle-route, so we were driven to strike out across the hills in a bee-line. The search for the easiest way up the sand-hills drove us gradually northward, till we crossed the highest part of the plateau. The so-called "sand-hills," like most of those we saw in the Lake Eyre basin, were not true sand-dunes or even sand-hills, but parallel ridges of loam, covered by a few feet of loose sand. Most of the ridges were low, and could be taken directly; but in a few cases the ascent was difficult, and the stock-whip had to be brought into use to urge the weaker

[1] Lewis's Journal of Lake Eyre Expedition (Parl. Pap., South Australia, 1875, No. 19, p. 7).

camels over the loose drift-sand, that formed the crest of the hill. The passage of these ridges would have been treated as child's play by a Somali camel-caravan; but with the Hergott system of loading and saddles the march was arduous, and with less judgment on the part of our camel-driver might easily have landed us in accidents.

We halted for lunch on a sand-hill, and the guides cheered us by pointing to a hill in the distance, which they said was Wanderapoolina, a hill some miles up the Macumba Valley, and on the other side of the Kallakoopah River. I was doubtful, but the guides were positive; so we had our frugal meal under the cheerful impression, that the distance across the delta had been greatly exaggerated. We pressed on, however, past several lake-beds, of which the last and the largest was named Piamurakinkaninna, *i.e.* "the lake of the bird that laughed." There are no laughing-jackasses in the Lake Eyre region. Does this name suggest that one of them had lost its way and wandered so far northward? Perhaps a poor, misguided laughing-jackass was also beguiled into a Kadimakara quest.

Towards evening we reached the hills that the guides had told us were on the other side of the Kallakoopah, and once again we found that their memories were at fault. Their notions of distance were very vague; a long course of neglected ophthalmia had, no doubt, injured their sight, till it was less perfect, for long distances, than that

of most of our party. Dampier referred to the natives as "the poor, blinking people of New Holland."

Sunset found us still on the plateau, with no sign of its edge, or of the end of the sand-capped ridges. We had no clue, except an uncertain estimate of time and pace, to tell us how far we had come; and we had an equally uncertain estimate, based on a small-scale map, as to the distance of the Kallakoopah Valley. So some of us hurried forward to solve this question before night. We raced up another ridge, the thirty-sixth that we had climbed that day, and found ourselves suddenly overlooking a broad lake-bed. Three miles ahead we could see the valley of the Macumba coming from the west; and a low gap to the north appeared to be the opening of the Kallakoopah, a branch of the Diamantina. This view was not exactly the one we had expected, for the map showed us a broad island between two arms of the Kallakoopah. Careful consideration of the situation, however, showed that the island on the map represented the lake-bed of Katakani. This discovery did not much surprise us, for we had long since learned that the ordinary geographical definitions do not always hold in Central Australia. A typical "lake" in this district is often found to be a level tract of land surrounded by higher, undulating ground.

We cheered the caravan forward with the news, that there was only one more sand-ridge to cross.

So the camels climbed up in the darkness to the fire we had already lighted, from the only clump of dead needle-bush that we could find along the ridge; and we had done our appointed day's march.

Next day we traversed the lake-bed of Katakani, until a bend in the river drove us on to the dunes. Both were soft, but we preferred the dry softness of the sand-hill to the wet softness of the swampy lake-bed. We crossed the Kallakoopah at a wretched ford, where one camel fell, load and all, into the bog. With strong language, and an uplift from half-a-dozen eager helpers, the animal was jerked to its feet, and we were saved the long delay that at first seemed inevitable. Pushing westward, we reached the Macumba, and marched quickly for several miles along its broad, open valley. We lost a good deal of time through the fussy anxiety of the guides to find a ford across the Macumba; they took us a mile and a half out of our way to cross a river-bed, which turned out to be only a branch channel on to an island; while farther up the river-bed was low and dry, and we could have crossed it anywhere.

The vegetation was better than any we had yet seen; there were acres of green samphire and flood-grass; and we forced our way through thickets of marsh-mallow, with woody stems fourteen feet in height. I cut one of them for use as a walking-stick, and it lasted throughout the rest of the expedition.

There was no sign of water or of a suitable site for a soakage. When at length we reached a part of the valley where the river had a more definite channel, and we found some water-holes, they were covered with salt; and the low-lying land on either side was impregnated with salt and alkali. The guides dug soakages, but, as was natural, they only got salt water. It was not until after dark, that the sudden flare of a fire told us that Jerry had found water. We marched towards it, feeling that, if the amount of water were in proportion to the size of Jerry's signal-fire, our difficulties would be at an end. But he had only found three old soakages by a deserted native camp. Our first impressions of the place were disappointing; of the three soakages, two were salt, and one "made" so slowly that our camel-driver said the place had been abandoned by the black-fellows as run dry. He declared that, though it might save one man from perishing, it was useless to us, let alone to our camels. As from this valley we had to make a long march over a plateau, where there was certainly no water, to a valley where there might be none, it was imperative to get water from the Macumba. So we camped beside the soakage to see what could be done with it by care and patience. We found that if we allowed the soakages to fill only from the top, they yielded a brackish water, which was good enough for the camels and for tea. The third and slowest soakage gave us water that was drinkable.

The camels were turned out to feed, the guides herding them to prevent their getting bogged around the salt-water pools in their efforts to get at the water. After the moon set the camels were tied down in camp; but guard had to be kept over them all night to haul them down whenever, in their attempts to escape to the water, they succeeded in struggling to their feet. Meanwhile, two of us were sitting in turn by the soakages, bailing out the water as it came in, so that they might run steadily all night. Whenever our improvised water-trough—a canvas tent-fly lining a trench in the sand—was full, we brought a couple of camels to empty it. Thus, by steady work all night, we watered the camels and got a fresh supply for ourselves, without delaying our march.

Next day, tired with our night's work, we rode sleepily up the Macumba Valley to its confluence with the Nardubuckina Creek at Paratattaninna. We found a corroboree-ground at this point, with some remains of dancing-sticks; but the aborigines had all gone, and there were apparently none left in the district. Another sign of the recent visit of the aborigines was a signal-pole, on the top of a hill overlooking the first water-hole up the Nardubuckina Creek. It had obviously been erected by people from the west, to attract the attention of people coming from the north or east.

Here I caught a small, white, poisonous snake the size of a worm, when digging for water in

the empty water-hole. The black-fellows regarded this snake with some alarm, and explained that it was very poisonous. It seemed very angry at being removed from its cool burrow; so I kept it on a patch of sand to see how long it would live there. The exposure to the heat killed it in three minutes.

Three miles up the Nardubuckina we crossed the creek, and found an old cattle-pad, leading up to the plateau. This was the first sign that we were on ground, that had been reached, in favourable seasons, from stations on the Transcontinental Road. But that stock had never been kept regularly in this area was shown by the abundance of feed; and Steer declared he had not seen anything like it, for more than ten years. Having reached the top of the plateau, we caught sight of the long, low line of the Desert Sandstone table-land at Wuntanoorinna, and we steered our course for its southern end.

The view across the plateau was wide, but melancholy. The near soil was reddish brown, strewn with patches of yellow sand, and bearing tufts of yellow grass-stems; but the cotton-bush looked as if it were really living, and the acacias had young green shoots on their black, dead branches. In the distance the colouring was sombre and dull; here and there were groves of needle-bush, which, by their dark green colour and cypress-like form, seemed better fitted to adorn a cemetery than to feed a camel. The only patch

of bright colour was in a small gap in the dull cloud-vault, that covered all the western sky, and through this gap could be seen a little cluster of more distant cumulo-stratus clouds, glowing with a rich Indian red.

Steer, who shared my camel, took a far more practical interest in the scenery. " My eye ! ain't the cotton-bush lovely ? Nine-inch lengths on it are eatable," he exclaimed in ecstasy.

We marched on till dark, and then had to go much farther before we could find a place with any firewood. As we were preparing our camp, we noticed a fire to the north of us. Donaldson and Dow rode off on Fireworks to reconnoitre, and came back with the news that there was a native camp a mile or so away. As soon as we lighted our fires, one of the aborigines came over to us. He was a tall, naked man, and looked half starved. He recognised Jerry, and it was amusing and half pathetic to see the man's joy at finding his old friend. He threw his arms round Jerry's neck, and shook with hysterical laughter, swaying from side to side. He told us his European name was Wood-duck Charlie, and that he belonged to Wood-duck Station, whither he was returning from a corroboree.

Next day Wood-duck Charlie attached himself to us as guide, and led us across the plains, which were once more of the stony desert type, to the water-hole at Wuntanoorinna. Here

there had been cattle-yards, used as an out-station from Wood-duck, and it was here that we had our one stroke of luck from the weather; for there had been a shower some days before, and some pools of fresh water were still left. They swarmed with animal life of the quaint, Central Australian, desert types, such as Estheria and Apus. We stopped here, Grayson collecting specimens of pond life, Voss Smith crustacea, and Donaldson water-plants.

After lunch we started westward again along an old dray-track from Wood-duck, the head-station of the Peak District. It led us past the southern end of the Desert Sandstone table-land of Wuntanoo-rinna, and a series of creek-beds lined with giji-trees. We pressed on till after dark, and about nine o'clock a short but terrific storm burst over us, as we were crossing a saddle between two hills. We had seen a storm brewing, but we lost sight of it after sunset, and gave no heed to it. We were marching slowly up a low valley leading to the saddle, for the camels were tired. It became pitch-dark, but some vivid lightning enabled us to keep along our route. Steer said the flashes were of unusual brilliancy, for he could not remember a more dazzling display. The hills on either side of the saddle were connected by an arch of cloud. As we rode towards it we noticed a weird light-effect. The sand-hill on the south of the pass appeared white during most of the time, while

it was outlined against the black clouds behind; when the lightning illuminated the sky, and the hill was in shadow, it appeared quite black; and then it slowly regained its whiteness, as if reacquiring a phosphorescent glow. The hills on each side were cloud-capped, and I thought that the clouds had sunk on to the saddle, and that we were walking up into them. But the saddle itself was just below the cloud-bank, and we began the descent of the western slope in face of a strong, hot wind. Suddenly the air changed in character, and rushed past us cool and damp, and we knew we were in for a rain-storm.

Steer proposed to stop; but as we were on the windward side of the gap, our position was especially exposed, and I thought it better to go on to the foot of the hill, where we might hope for comparative shelter and some firewood. The wind was terrific; one man's pith helmet was blown from his head, and its recovery was hopeless. We had to keep the camels directly facing the wind, or they began to make such leeway, that it would have been impossible to guide them; but the animals bravely pressed on against the storm. In a few minutes after the rush of cool air the rain began. The first drops tasted like brine, for they were a mixture of water and salt dust. But the rain soon became fresh; the drops were large and heavy, and they struck our faces like hail. At first I thought

it must be hail; so I opened my mouth as an extempore rain-gauge. But no hail fell into it—only delightfully cool, fresh water.

The noise of the storm was deafening; orders were impossible, as no one could hear them. We soon reached the plain, and halted till the storm should pass, when the camels suddenly lost their self-control and each swung round to get its back to the wind. They broke their nose-strings and huddled together, knocking their loads against one another, but fortunately without doing any damage. The lightning-flashes showed a water-course, lined with giji-trees, a little ahead of us; and at the first lull we went to its edge and camped. Unfastening the camel loads was a troublesome task, as all the knots had jammed with the shrinkage of the wet ropes, and we were in an especial hurry to untie them, that the camels might get a drink from the water in the foot-holes, which was being fast absorbed by the thirsty soil. As our blankets were used as saddle-cushions, they were sopping wet as well as our clothes, and we were all shivering with cold till, after much trouble, we got a fire lighted and made some hot tea. The rain that we had wanted so badly, all the earlier part of our journey, had come now that it could do us no good, and could only hinder us by making the tracks soft and slippery.

A short march next day took us to Wood-duck Station, which, to our disappointment, was unoccupied. Mr. and Mrs. Kempe had temporarily

Northern End of the Peak Range from the Neale River. White Colour due to the Abundance of Quartz Fragments.

abandoned it owing to the complete failure of the water-supply, and they had withdrawn to the old station at the Peak, twenty-five miles farther to the west. But we stayed at Wood-duck for lunch, and in the afternoon went on to the Neales River, and camped within sight of the old ranges, that form the western rim of the Lake Eyre basin. Next day we reached the Peak Station, where we received a most hospitable welcome from Mr. and Mrs. Kempe.

Our interesting friend, Wood-duck Charlie, had told us that he was going back to his tribe to teach it a corroboree, which had been invented by some native genius away up in Queensland. He had learnt it from some of the Cowarie tribes at the corroboree-ground, that we had passed on the Macumba. We had asked Wood-duck Charlie to arrange the first performance on the night of our arrival, so that we might see it; but he declared it was impossible, as they would have to wait for a fortnight for the dark, moonless nights.

Dow, who was an enthusiastic student of the ways of the aborigines, was quite ready to stop behind for a fortnight, if he could be sure of seeing the corroboree, and on our arrival at the Peak, he promptly made inquiries as to whether it would be sure to take place within the appointed time. To our surprise and Charlie's disgust, we found that another party of natives had got in before him, and were already teaching the

same corroboree to the people of the Peak. The last of the five performances was to take place that night. It was a highly respectable, family corroboree; women were admitted to it, and there was no objection to our presence. We were eager to see it; but the performance could not begin until after sundown, and the fortnightly train to the south left Warrina at nine o'clock the next morning. Mr. Grayson kindly volunteered to go on to Warrina with Steer and the camels, and get everything packed ready for the train. This generous offer enabled the rest of us to spend the day with Mr. Kempe at the station, and attend part of the last performance.

Meanwhile, Mr. Kempe showed us where to collect some interesting fossils, and told us many stories about the aborigines. He was more critical of the people than were the missionaries at Kilalpaninna. But he appreciated their good points, and was obviously very successful in handling them. He especially objected to their receiving an ordinary, scholastic education. He was in favour of a strictly technical training in pastoral and agricultural subjects.

After tea, the five of us who were going to the corroboree mounted our camels and followed a guide whom Mr. Kempe had lent us. The guide was mounted on a light dromedary, and it was all we could do to keep up with him on our heavy camels. But separation from our guide, in the scrub along the Neales River, would have meant

the loss of the corroboree, and perhaps also of our train next day. We hurried on our camels, and after a quick ride of a few miles we reached the camp, where a large crowd of aborigines were already assembled. The place was infested with an enormous pack of half-starved dogs, and I congratulated one of the leading aborigines on their number. The man glanced round at the animals with an air half of pity for my ignorance and half of apology for the dogs, and explained with the air of a connoisseur, " They're all mongrels, sir; they're all mongrels."

We stopped for a short time among the aborigines, and we used the interval before the corroboree in a brisk bazaar, which lasted till we had cleared the camp of spears and shields, and our pockets were empty of money.

What we saw of the corroboree is described in a later chapter (XIII.). Unfortunately we could not stop for the whole of it, as it was to last all night, and our train, which ran only once a fortnight, was to leave Warrina station early next morning.

We had to go back some miles to the Peak, thence we had a twelve-mile journey over the hills to Warrina; and it would have been unsafe to delay our start, as the moon set at about one o'clock in the morning. So we mounted our camels, said good-bye to the aborigines, and rode back to the station. Mr. Kempe kindly gave us supper, and at eleven o'clock we left his hospit-

able home, and followed the guide up a rough, stony track on to the mountain-range, that forms part of the western rim of the Lake Eyre basin.

So long as the moon was above the horizon we managed well; but it sank below a bank of clouds, before we were clear of the hills. We had to find our way across the great western plains in utter darkness. We made but slow progress, and I was beginning to think that our guide was out of his bearings; when suddenly—we stumbled across the railway line, which seemed out of place in such a wilderness. We followed it for half a mile, and at 2 a.m. we saw the flicker of a dying fire, which told us where the caravan was camped, and our supper was awaiting us. To the cheering strains of Guy Smith's rendering of, what seemed to be, a combination of the Hallelujah Chorus and the Melbourne University Anthem, we rode our camels into the Warrina station-yard.

The fortnightly train was expected in seven hours' time, so we had won the race from Kalamurina, and had finished our traverse of the hottest and dustiest depression in the hot and dusty continent of Australia.

THE LAST MARCH. MR. GRAYSON TAKING THE BAGGAGE CAMELS ACROSS THE PEAK RANGE.

PART III

THE LAKE EYRE BASIN

CHAPTER X

THE DEAD HEART OF AUSTRALIA

Now reigns the blazing furnace of full noon.
RODEN NOEL.

THE objects of the expedition to Lake Eyre were to secure a collection of the fossils of that area, to determine with greater precision the age of the giant marsupials that once lived there, to gain further information as to the geological history of Central Australia, and to see what light geology could throw on the legends and original home of the aborigines.

We selected Lake Eyre as our field of work, not because we thought that its climate made it the most suitable place in Australia for a mid-summer vacation, but because it is in an area of especial importance in the natural science of Australia. For Lake Eyre, with its coasts and estuaries, was once the living heart of Australia. It is not, and may never have been, the topographical centre of the continent,[1] although it was

[1] The centre of Australia is popularly regarded as at Central Mount Stuart, although the excentric position of that mountain has been clearly pointed out. Thus C. H. Barton (*Outlines of Australian Physiography*, 1895, pp. 9, 10) remarks : " Stuart, the explorer, fixed the centre of the

once nearer thereto than it is now. But it may fairly be described as the geographical centre; for it was once the main distributive centre, and it is connected with each of the four chief divisions of Central Australia. It includes part of the deep reservoir of subterranean water, which embraces most of the north-eastern quarter of the continent. Its western rim is formed by the eastern slope of the apparently eternal plateau of Western Australia. A detached fragment of its floor now lies at the northern end of Lake Torrens, and links the Lake Eyre basin to the Great Valley of South Australia. Finally, it is an essential part of the vast plain which extends from the Great Northern Railway of South Australia eastward to the Darling.

As regards the botany, zoology, and anthropology of Australia Lake Eyre has played an important part. It gives its name to the largest of the three provinces into which Australia has been divided on biological evidence; for it is the typical district of the "Eremian" region, proposed by the late Professor Tate, from the evidence of plant dis-

continent at the intersection of the 134th meridian with the parallel of 21 degrees 30 minutes of south latitude, and marked the spot by bestowing on a neighbouring hill the name of 'Central Mount Stuart.' It is questionable, however, whether this mode of determining the centre of a mass of land be not fallacious, and whether the true centre should not be sought about 25 degrees south and 135 degrees east, that point being farthest removed from the sea, exactly equidistant from the north and south, and very nearly so from the east and west coasts." Barton's centre, about 60 miles north of Charlotte Waters, and about 225 miles southward from Stuart's centre, appears the better selection.

tribution; and it suggested the name of the "Eyrean Province," proposed by Professor Spencer, in consideration of the distribution of Australian animals. Anthropologically Lake Eyre is important, as it was the headquarters of the natives of the two-class marriage group, who advanced thence south-westward to the Eyre Peninsula, and spread south-eastward until they peopled Western Victoria.

Lake Eyre, however, long since lost its importance as an active and creative centre. It still receives the water drained off five hundred thousand square miles of country, and it absorbs it all; for the lake has no outlet, and none of the water it receives is passed on to areas, that would make better use of it. Animals and plants are continually emigrating into the Lake Eyre basin from the surrounding highlands; but these reinforcements are insufficient to make good the internal waste. Great hordes of rabbits invade it, only to perish when the plains are stricken with drought. Mobs of cattle are driven on to its pastures, too often to die, overwhelmed by dust-storms, or miserably bogged in the mud of the drying water-holes. The insatiable desert now produces little new; its plants and animals are few in number and in kind, and they are stunted in their individual growth.

The reasons why this region, once fertile and creative, has become barren and inert have to be sought in the geological history of the Lake

Eyre basin. We have to go back to the time that followed the formation, in Australia, of the Gippsland coalfields, and, in England, of the limestones around the city of Bath. The region of Lake Eyre was then slowly sinking, till it was flooded by a sea, which steadily encroached from the north. The margin of this sea was overspread by a vast sheet of sand and gravel; and these deposits were subsequently buried by layers of mud, formed in deeper water, further from the shore, which extended from the Gulf of Carpentaria southward, across Western Queensland, and through the northern and north-eastern parts of South Australia. The central inland sea, which now invaded the continent, was bounded on the east by the main ranges of Queensland, and to the west by the plateau of Western Australia; on the south its farthest gulf ran along what is now Stuart's Creek, between the Willouran and Denison Ranges, and it thus reached the northern end of Lake Torrens.

The sea subsequently retreated, and once again the great basin of Central Australia became land. The muds that had been deposited on the sea-floor hardened into a sheet of impermeable blue clay, and were covered by a wide sheet of sands, loams, and gravels that formed what is known as the Desert Sandstone. A great uplift then occurred in Eastern Queensland. The Desert Sandstone and the underlying blue clays have been partly worn away by wind and rain and river action, and a

broad band of the sandstone and gravels below the clay has been exposed on the western flank of the Queensland Highlands. The rains upon these hills feed many streams, which flow down the western slope until they are sucked up by the thirsty air, or sink into the porous sandstone. Any water that may pass underground filters away southward and westward, beneath the overlying cap of blue clay, and is added to the stores of water in the great subterranean reservoir of Central Australia.

While these geographical movements were slowly in progress in the north, great changes were taking place to the south. The sea, after withdrawing from Northern Australia, began to encroach on the south, in consequence of successive subsidences of the ground, till it washed the whole coast of Southern Australia, from the head of the Australian Bight on the west to the Snowy River on the east. The sea spread over much of what are now the coast-lands of South Australia and Victoria, and extended in gulfs far inland, especially up the basin of the Murray; so that the Darling, the Murrumbidgee, and the Hume (*i.e.* the Upper Murray) entered the sea as independent rivers.

Then followed a series of powerful earth-movements, which impressed on South Australia the last of its main, existing, geographical features. A double set of parallel faults broke across Southern Australia, and allowed the long band of country between them to sink slowly, producing the Rift

Valley of South Australia. The floor of the southern part of this valley foundered beneath the sea, and thus formed Spencer's Gulf, while the northern part of it remained above sea-level as the long basin of Lake Torrens.

At about the time of these movements there was a great change in the Lake Eyre country. The district began to sink again, and this movement continued till the lake-margin is now thirty-nine feet below sea-level. The sinking of this area disturbed the whole river system of Central Australia. In all probability, the rivers which belong to the Lake Eyre system previously flowed south-eastward, and either joined the Darling or had an independent entrance to the sea that ran up the Murray Valley. As the depression of Lake Eyre deepened, the Cooper and Diamantina were diverted into its basin, where they accumulated as a vast inland sea. Round such a sheet of water there must have been a heavy dew, and probably the rainfall was also considerable; for the adjacent steppes were well grassed and fertile, and large trees—now represented by their petrified trunks—grew on the plains. The water of this lake was fresh, and on its eastern shore the rivers from the north-east were broken up by deltas, and deposited some broad sheets of rich delta-loams. The lake at this time was probably at least three times the size of its present bed; and on its shores lived many giant kangaroos and giant wombats, as well as wallabies, bandicoots, and marsupial rats. Croco-

diles swarmed in the lake and its estuaries, and preyed on the primitive Queensland mudfish (*Ceratodus*) and on huge, bony fish, all of which have long since disappeared from the waters of the Lake Eyre basin.

Unfortunately for the economic prosperity of Central Australia, this condition of affairs did not endure. The rainfall dwindled, the water-level sank, and the lake decreased in size. The discharge from the lake was no longer sufficient to keep open its channel, which the warping of the surface and the accumulation of debris continually tended to close. Accordingly Lake Eyre lost its outlet; its waters were henceforth removed only by evaporation; the salts, carried into the lake by the rivers, were concentrated, until the waters became salt and the fish and crocodiles were all destroyed. As the lake shrank in area, less and less rain fell upon its shores; the vegetation withered; the once green, succulent herbage was replaced by dry, spiny plants; the giant marsupials died of hunger and thirst; hot winds swept across the dusty plains, and the once fertile basin of Lake Eyre was blasted into desert.

To obtain light on the age of this desiccation was one of the main objects of our journey to Lake Eyre. Most of the evidence obtained is too technical to be stated here, but one important piece of it can be easily explained. We discovered remains of the dingo in association with the extinct marsupials. It is held by some authorities that

the dingoes were introduced into Australia by man; but we found no trace whatever of man or his implements in association with their bones. Had man been in Central Australia at that time we should probably have found some trace of his presence. We searched in vain for stone implements derived from the bone-deposits. Considering the extravagant untidiness with which the aborigines scattered stone-flakes about their camps, it is improbable, had man been contemporary with the animals, that our party would not have found some of these implements. It therefore seems probable that the great climatic changes in Lake Eyre occurred after the introduction of the dingo, and before the advent of man to this region.

Moreover, we found the dingo associated with the carnivorous marsupial, the Thylacinus, which is now found living only in Tasmania. And as the dingo, the giant marsupials, and the lyre-bird never reached that island, it is probable that Bass Strait was formed after the development of the Thylacinus and before the arrival of the dingo. If the Tasmanians, as Mr. Howitt thinks, crossed to Tasmania from Victoria by land, then the Tasmanians must have been in Australia before the dingo, and before the evolution of the giant marsupials. The Tasmanian aborigines would, in that case, date from the geological age known as the Pliocene. That conclusion is, however, improbable; but there is considerable evidence to show that the older marsupial beds of Lake Eyre

belong to the Pliocene; and the age of the desiccation of Central Australia doubtless began early in the succeeding period, the Pleistocene—the age which includes the present time.

The age of the desiccation of Central Australia bears on a problem of world-wide importance. Many different parts of the world show evidence of a similar climatic change. The deserts in South Africa have encroached on once fertile districts; and there is evidence of the former existence of considerable rivers in now arid regions. Palestine has ceased to be a land flowing with milk and honey; and on the plateau of Central Asia, the ruins of old towns and large monasteries have been buried by invading sands, which have driven the inhabitants from their homes. Russian lakes and swamps have been drying up. In South America we have evidence of similar changes, as the glaciers have dwindled, lakes have disappeared, and Sir Martin Conway has described traces of agriculture, in regions where no crops can now be grown. According to Prince Krapotkin, the whole world has been passing through a period of desiccation, which may not yet have reached its maximum.

We may take comfort against any alarmist fears of an approaching cycle of universal drought, in the fact that the total rainfall on the earth must remain approximately the same, unless there be a great reduction in the heat emitted from the sun, or a variation in the relative areas of land and water on the globe. Without such changes we

have only to consider a different distribution of the rainfall, and not any serious alteration in its amount. Hence it is only natural that, if we have evidence of lessened rainfall in one area, we should have equally clear proof of an increased precipitation in another. There is nothing inconsistent in the disappearance of springs in Palestine at the same time that the Swiss glaciers increased in size. Hence we do not need a period of universal desiccation to explain the withering of Lake Eyre. It may have been drying up, while other parts of Australia have been having a larger rainfall. The loss of the rains, that once fell in the interior of Australia, may correspond with an increase in the wastefully excessive rainfall on the Tasmanian hills.

The fact that the desiccation of the Lake Eyre basin began early in the Pleistocene era is of much interest; for the great variation in its geographical conditions is due to the severe climatic changes, which at that date affected many far-distant regions of the globe.

CHAPTER XI

THE CHARM OF THE DESERT

Lord of peoples, lord of lands,
Look across these shining sands—
Through the furnace of the noon,
Through the white light of the moon.
Strong the Ghiblee wind is blowing,
Strange and large the world is growing!
Speak and tell us where we are going,
    Where are we going, Rubee?

. . . .
. . . .

Stranger round us day by day
Bends the desert circle gray;
Wild the waves of sand are flowing,
Hot the winds above them blowing,—
Lord of all things!—where are we going?
    Where are we going, Rubee?
        WHITTIER, *Song of Slaves in the Desert.*

THE early travellers into the Lake Eyre basin sent back contradictory descriptions of the country. According to Eyre and Sturt, it was a desert of the worst type; according to Howitt, Davis, and McKinley—all three of whom went there to search for the lost expedition of Burke and Wills—it was a fertile land of lakes and rivers and meadows, and was well adapted for pastoral settlement. Full confirmation of the latter view—to the confusion

of those who had formed the first opinion—appeared to be given in the seventies, when large tracts of country around Lake Eyre were "taken up" for pastoral purposes.

Cattle stations were founded—and flourished—where Sturt had found existence intolerable and barely possible, and where Burke and Wills had perished of starvation. The success of the cattle industry led to the view, that it is inaccurate to describe the Lake Eyre basin as a desert. This idea, however, is based on an extreme definition of the word "desert," which would restrict it to localities bare alike of vegetation, animal life, and moisture. This use of the word would prevent its application to most of the deserts of Africa and Arabia, as well as to the "desert places" of the Gospels. If such a definition were insisted on, the name of the Great Desert Girdle for the band which extends from the Atlantic to Tibet would be a misnomer, and the deserts of the world would shrink to some small, isolated patches.

Even, however, with such an exacting definition of the term "desert" some of the Lake Eyre region would be fully entitled to the name; for there is nothing on earth more desolate than its stony plains and bare clay-pans, while in the ordinary geographical use of the term, it may be fairly applied to the less arid loam-plains and sand-ridges of that region.

The fact that men once settled on these barren wastes—and will settle there again, when the

drought that oppressed them during our visit has passed—does not disprove their desert character. It shows that the desert is not so barren as has been represented, and that it has a fascination which, to some minds, is irresistible.

The source of the desert's fascination is puzzling. The yearning to discover the secrets of the unknown, which leads one man to spend his life in the chemical laboratory, sends another to explore the pathless desert. But even after the pioneers shall have discovered all its secrets, the desert will still have a charm as irresistible to those who feel it, as the spell which the sea throws over its lovers.

The resemblances between the desert and the sea are proverbial. Analogies have often been drawn between travel on the sea and travel in the desert—over its wind-raised dune-waves, across its shore-like tracts of sand, and past its sheets of brine to the welcome havens in its oases, scattered like islands in the waste. The camel's familiar name of the "ship of the desert" shows how widely the idea has spread.

In my boyish yearning for the opportunity of travel, I was always more attracted by lands than by seas; and of all the types of foreign land, I felt most interested in the desert. When an opportunity came to me to visit the Western States of America, a glimpse of the deserts in the western basin was resolutely included in my programme. Great was my delight, when I left a back-bush

railway station for a short excursion across the salt desert of Utah. But the joy soon proved to be somewhat fearful. There was a strong head-wind, which blew the salt-dust on to my dry lips and into my eyes, till they smarted sorely; the heat cracked my town-bred skin; and my horse, stumbling over a cactus-bush, threw me into it, so that my hands and face bristled with cactus-needles.

With smarting lips, aching eyes, and pricking skin, I decided that I had struck a bad specimen of desert; and I passed not unwillingly from the salt desert to a lava desert, which looked more attractive as I reached its edge, at the western foot of the Great Tetons. Its surface was black and rocky, and it promised to be free from glare, salt-dust, and cactus. But next day, at noon, the black soil seemed to get as hot as a stove-top; the skin under my chin was sun-blistered by the heat reflected from the ground; a westerly gale pelted us with coarse, black grit; and the water in our leather water-bags became warm and putrid, and almost poisonous. I was forced to confess that I had struck another unsatisfactory type of desert, and turned with relief from the Idaho lava-plain to the plateaus and canyons of the Rocky Mountains.

Since then I have tried several other sorts of deserts, but though none of them have come up to my boyish dreams of their beauty and romance, ever and anon I feel a longing to see the great

bare desert again—to enjoy once more its soothing solitude, and the exhilaration of its buoyant sense of freedom. The world never feels so wide and so unfettered as in the desert, with its low horizon, its long, open curves, and its unequalled expanse of sky.

It is difficult to express the charm of the desert, and perhaps impossible to make a town-dweller believe in it. It is much easier to explain the drawbacks, for they can be stated as a series of crude facts, whereas the attraction is a matter of sympathy that must be felt. Life in the desert is not all picnic, and in the daytime especially, the desert tends to rouse one's hostile and combative instincts. The desert then has a way of disguising itself as an enemy that must be fought. Its distances are vast, and they have to be wearily traversed; its heat is intense, and it has to be patiently endured; its secret water-holes have to be traced by the few faint clues, which even the subtle ingenuity of Nature has not been able to conceal. During daytime in the desert one appreciates Shelley's preference for the night.

> When light rode high, and the dew was gone,
> And noon lay heavy on flower and tree,
> And the weary day turned to his rest,
> Lingering like an unloved guest,
> I sighed for thee.

While the desert may thus appear as a passive foe, its creator, the sun, behaves as an active enemy.

"When the sun was as a menace, glaring from a sky of brass," one follows it in its fiery march with feelings that sometimes approach to hatred. The sun is the direct cause of the cloudless sky; it has caused the foliage to shrivel into needles, or the trees to hang their leaves vertically, so that they throw no shade beneath; it dries the air to its utmost transparency to heat; and it bakes the soil, until it is hard and arid. But for the malevolent energy of the sun, the country might be fertile as in the days of the extinct Kadimakara, and the scenery would be softened by atmospheric effects; so that one would no longer get only the inconvenience, and none of the beauty, of distance.

The conditions of desert travel are generally severe, although a camel-train, with its stores and water-bags, gives ample food and safety. At times, when the caravan is hidden below a sand-ridge, the horror of being hopelessly lost in the desert—waterless and foodless—forces itself upon one's mind. We think of the unfortunate travellers whose bones, bared by dingoes and polished by sand, lie scattered on the Central Australian wastes. A vision rises before us of the desperate struggles of the lost explorer, and of the despair of his last mile's march. We begin to realise the agony of death by thirst, when the sun is burning like fire, and perhaps swarms of ants are stinging like a medieval "jailer's daughter." We then understand how Nature can rival the malignant tortures of

the Inquisition. The desert is not attractive when it presents itself in this mood, which is that generally represented by the poets, as in Kendal's

> On the tracts of thirst and furnace—on the dumb, blind, burning plain,
> Where the red earth gapes for moisture, and the wan leaves hiss for rain.

But at night every aspect of the desert is changed; we are no longer struggling with difficulties, but resting peacefully, and inclined to feel in harmony, rather than in conflict, with our surroundings. The air is cool and bracing; the low, brown hills that looked so near, but are so far, can no longer mock, or the mirage tantalise. Instead of a waste of glaring yellow sand we look up at the noble expanse of dark blue sky, lighted by the glittering stars, and perhaps by a faint cone of zodiacal light. We feel that Ruskin may be right in his opinion about the sky: "It is the part of creation in which Nature has done more for the sake of pleasing man, more for the sole and evident purpose of talking to him and teaching him, than in any other of her works, and it is just the part in which we least attend to her." Slowly the charm of the desert enters our souls, and drives away the demon dread of day.

Certainly one of the main charms of the desert is the sky. Never does it look so solid, nor feel so close. Nowhere else do we feel so sceptical of astronomical distances; for as the night wears on the sky seems to creep down closer, until it appears

almost within touching distance, and to have wrapt the earth in a celestial peace. Lying in the open, one hears every sound; and in the intervals revels in the musical silence of the night.

No other silence is as absolute as that of the desert. At sea, even on a sailing-ship in a dead calm, there are jarring noises—an occasional jerk of the rigging, or the creaking of a mast, or the idle flap of a sail. But night in the desert brings absolute silence. At first the perfect stillness is disturbed by the clank of hobble-chains; by the crackling of the cooling embers or stones beneath the fire; and by the screech of the goliah-parrot, the coo of the pigeon, and the hoot of the owl, till the last bird has flown back from the water-hole to its safe nest in the scrub. At length the camels grow quiet or wander out of hearing, the embers are cold, even the last prowling dingo has gone to its lair, and there is nothing to break the absolute quiet but the steady, audible thump of one's own heart. The camp is wrapped in a silence that appears to have crept down with the stars, and is more delicious than the sweetest music. At times this perfect peace is gently broken by a faint, barely perceptible humming, caused perhaps by the wind rustling some distant scrub, or the trickle of blood through the capillaries of the brain. But one is tempted to believe it to be "sphere music, such as that you dream'd about"—the hum of the moving stars sweeping across the hard, low roof of the sky.

Feeling so close to the stars, and so intimate with them, enjoying the glory of the solitude and silence, even the idea of death in the desert loses its horrors. The delights of peace and rest and harmony with one's surroundings appear heavenly. The passage from the strenuous struggle of the day, with the garish, glaring sunlight, to the full peace and soft beauty of the darkness seems emblematic of the passage from life to death. No other conditions present death in a more attractive guise. Nowhere else can the joy of rest be more truly appreciated and the beauty of darkness be more fully realised. "The darkness of death," says Richter, "is like the evening twilight—it makes all objects appear more lovely to the dying." As we keep our watch in the desert-camp, we seem to have half crossed the threshold of the star zone, and we feel an irresistible attraction towards the better rest and fuller silence of the long, desert journey, that lies before us all.

The desert, however, not only projects our imagination into the future—not only is it true, as an Oriental proverb says, that "the desert is the garden of Allah"—but at the same time it recalls instincts and recollections from the past. The simplicity of desert life, the uniformity of its conditions, the merciless severity of its forces, awaken in us the primitive man, lying beneath the carefully built-up fabric of social obligations. The unchanging face of Nature dimly stirs the beginnings

of man. His pushing forward into the unknown is as the crown and completion of those beginnings. It is this combination of the feelings of the past and of the future, that gives the desert its peculiar fascination—as, for a moment, a man sums up in himself the long experience of his race. To retain the knowledge and thought of the twentieth century while meeting the conditions of prehistoric man, to face the mystery of the unchanging desert, divested of the fetish-begotten fears that half paralysed the primitive races, gives that stimulus to the imagination, which is one of the highest joys given to man to feel.

The explanation that the charm of the desert is an appeal to the imagination, an impulse from "the soul that is not man's soul," not only tells us why the desert charms, but why this charm is not universal. Men's minds are very diverse. The impulse, that in one man rouses the sense of mystery, stirs in another the sense of beauty; and those whose minds are chiefly stirred by that beauty of form which we call "art," or that beauty of life which we call "goodness," may prefer regions where "the riddle of this painful earth" is less obtrusive than on the dreary wastes of those

> Deserts thorny, hot and thirsty, where the feet of men are strange,
> And Eternal Nature sleeps in solitudes which know no change.

KARKALINA, A MEMBER OF THE DIERI TRIBE, EAST OF LAKE EYRE (AGED ABOUT FIFTY YEARS).

DALBIRIKA, A MEMBER OF THE YAUROKA TRIBE, NORTH OF LAKE HOWITT, COOPER'S CREEK.

WOLPILINA, A YANTRUWUNTA, FROM NORTH-EAST OF LAKE GREGORY.

A YAUROKA, FROM THE LAKE HOWITT COUNTRY.

CHAPTER XII

THE ABORIGINES OF LAKE EYRE

I cannot loathe nor scorn the colour'd man;
Nor deem him far below my Master's love.
I know about the sutures of his skull,
But I have proved him verily my brother.

RODEN NOEL.

1. THE ALLEGED DEGRADATION OF THE AUSTRALIAN ABORIGINES

THE basin of Lake Eyre is of especial interest to students of anthropology, for in it are found the survivors of the most primitive of Australian tribes, and perhaps the most archaic social system, that still exists upon the earth.

There is a widespread belief that the Australian aborigines are the most degraded members of the human family. For instance, a recent article[1] on

[1] *The Nineteenth Century*, January, 1905, p. 89.

"The Position of the Australian Aborigines in the Scale of Human Intelligence," by the Hon. J. Mildred Creed, opens with the statement, that "it is generally accepted that the aborigines of Australia are a race very low in the intellectual scale of humanity. This belief has remained uncontradicted for a century." This view is taught not only in popular and geographical works, but in standard compilations, and even in scientific anthropological literature.

The author quoted above continues (*op. cit.* p. 96), "The mental degradation of the autochthones of Australia has been so generally and unhesitatingly asserted, that with the average writer on ethnology it has become an accepted phrase." She quotes, as illustrations, passages from two books, both published in 1901, in one of which W. H. Thomas, on *The American Negro*, describes the Australian negro as "the zero, so to speak, of all anthropological analysis"; and in the other, Meredith Townsend, in his *Asia and Europe*, speaks of the Australian blacks as being "the lowest of savages."

Such quotations could be multiplied indefinitely. According to the late Professor Ratzel, the Australian aborigines possessed but a "vacuous mind." J. G. Frazer, in one of his latest papers,[1] observes that the Central Australians "rank with the lowest races in the scale of humanity." Andrew

[1] J. G. Frazer, "On Some Ceremonies of the Central Australian Tribes," *Rep. Austr. Ass. Adv. Sci.*, vol. viii. (1901), p. 313.

Lang remarks,[1] "The manners and rites of the natives were far the most archaic of all with which we are acquainted. Temples they had none: no images of gods, no altars of sacrifice; scarce any memorials of the dead. Their worship at best was offered in hymns to some vague, half-forgotten deity or First Maker of things, a god decrepit from age or all but careless of his children."

The belief in the extreme degradation of the Australian aborigines dates from the early days of the British occupation of the continent. The information available in 1829 was fairly summarised by *The London Encyclopædia*[2] in the following passage: "The natives of Australasia are, for the major part, of a decisively African or negro character; and nowhere is human nature formed in a more degrading state. An enormous head, flat countenance, and long slender extremities mark their physical conformation, together with an acuteness of sight and hearing; but, often half starved, their strength is generally less than that of the inhabitants of other climes. In no part of these seas is the population great. Not more than twenty thousand inhabitants have been seen on all the coasts of these islands taken together. Of natural affections little of course appears, and of religion absolutely nothing. Mothers have scarcely the regard of the brute creation for their offspring. They will

[1] In Mrs. K. Langloh Parker, *Australian Legendary Tales, Folklore of the Noongahburrahs as told to the Picaninnies*, Introduction by Andrew Lang, 1896, p. xiv.

[2] London, 1829, vol. iii. p. 296.

commonly procure abortion by violent means; and sometimes adopt the horrible expedient of burying their children alive, to be freed of the trouble of them. An inhabitant of New Holland knocks down the woman of his choice with a club in the presence of her friends, and takes her into the woods while in a state of insensibility. Here the alliance is preserved as long as he finds it convenient; he then deserts her for a new wife, who is similarly obtained."

2. LITTLE EVIDENCE IN ITS SUPPORT.

Such wild misrepresentations have been often and authoritatively contradicted. Pickering[1] tells us that, "strange as it may appear, I would refer to an Australian as the finest model of the human proportions I have ever met with; in muscular development combining perfect symmetry, activity, and strength; while his head might have compared with an antique bust of a philosopher."

Huxley,[2] who enjoyed early Australian experience, expressed the emphatic opinion that the aborigines are not negroes, and are nearly related to the ancient Egyptians—assuredly no degraded race. He says that "although the Egyptian has been modified by civilisation, and probably by admixture, he still retains the dark skin, the black, silky, wavy hair, the long skull, the fleshy lips, the broadish alae of the nose which we know dis-

[1] Charles Pickering, *The Races of Man*, 1850, p. 139.

[2] T. H. Huxley, "On the Geographical Distribution of the Chief Modifications of Mankind," *Journ. Ethn. Soc.*, vol. ii. (1870), pp. 404–5.

tinguished his remote ancestors, and which cause both him and them to approach the Australian and the 'Dasyu' more nearly than they do any other form of mankind." He continues: "The only people out of Australia who present the chief characteristics of the Australians in a well-marked form are the so-called hill-tribes who inhabit the interior of the Dekhan, in Hindostan. An ordinary coolie—such as may be seen among the crew of any recently returned East Indiaman—if he were stripped to the skin, would pass muster very well for an Australian, though he is ordinarily less coarse in skull and jaw." Pickering[1] also refers to the striking resemblance of some Indians to the Australians.

Most competent authorities, who have had personal intercourse with the aborigines, repudiate the reports of their brutal disposition. Thus, according to Spencer and Gillen, the natives are generous; they are considerate to one another and especially kind to the aged and infirm; the authors show that the charge of ingratitude, so often made against the aborigines, is based on a misconception. Mathew, again, describes them as a "weak, peaceful, kindly people."

The popular conception of the mental and moral characters of the Australian aborigines is as erroneous as the caricature of their personal appearance. The extreme kindliness of the people, especially to the old, is one of their most striking

[1] Pickering, *op. cit.*, pp. 145-6.

characteristics. Instead of being cruel and wholly devoid of affection, they show a fondness for their children and a generous consideration for the old and infirm members of their clan unusual among primitive people.

The yarns about the marriage of the women after they have been knocked insensible by a club, the stories of the starvation of the old and infirm, and the cruelty to children may all be dismissed. There are acts of individual brutality—but what race is free from them?

The alleged mental degradation of the aborigines has but little evidence in its support. The reports of the Government school inspectors show, that the aborigines are unusually quick pupils. On more than one occasion, a school in one of the aboriginal reserves of Victoria has been first in order of merit among all the public schools of the State.

Instead of being able to count only up to five, as is often asserted, the aborigines are trusted to count big mobs of sheep, and do the work as accurately as a European.

Their religion, it is true, is a simple form of fetishism. But such as it is, they have a real belief in it, in the immortality of their souls, and in the existence of a spiritual world. Some of the tribes have belief in an "All-father." It has been suggested that this idea has only been adopted from the missionaries; but it was certainly not European influence, which suggested

the appeals to the Kadimakara to control the rain, or the propitiatory rites which Spencer and Gillen have shown, that the Warramunga pay to the spirit of the mythical animal, the Wollunqua.

The evidence in favour of the aborigines has been swept away by the amount and the simple directness of the contrary opinion; and I entered the Lake Eyre region, sharing the popular prejudice. As the Dieri tribe, which lives around the mission station at Kilalpaninna, is often taken as the type of the most primitive group of the aborigines, I expected to find them intellectually much lower than the negro, and in a condition of worse savagery than the pygmies of Equatorial Africa.

My first meeting with Australian aborigines was on entering the village of Kilalpaninna. I had walked on ahead of the caravan, and, meeting some natives, asked them for guidance. Instead of a reply in nigger patois, one of the men explained, in excellent English, the arrangements that had been made for us and where our camels could best unload. My surprise on this occasion was increased with further experience of the aborigines. Instead of finding them degraded, lazy, selfish, savage, they were courteous and intelligent, generous even to the point of imprudence, and phenomenally honest; while in the field, they proved to be born naturalists and superb bushmen. Of course there are exceptions.

Though industrious over work that interested them, their most common fault is laziness; and their most irritating characteristic is that their notion of truth, though well above the average of coloured peoples, is not up to that exceptionally high standard, which is one of the special virtues of the Teutonic race. Nevertheless, before our stay at Kilalpaninna had come to an end, we all shared the feeling, that of all the quaint delusions respecting Australia, the quaintest is that which represents its aborigines as the most useless and untrainable of savages.

The old notion was probably first based on the low standard of Australian arts and industries. The aborigines had no knowledge of metals, and used stone implements; so they were compared with the stone-using people of prehistoric times. In spite of the inclemency of the climate, with its rapid changes from blistering sun to chilling rain, they wore no clothes and built no permanent huts: their only shelters were caves and rough screens and bivouacs. Their boats are canoes of bent strips of bark; their weapons of war and the chase are spears of pointed wood and various forms of simple missiles—for they are ignorant of even the bow and arrow.

The inference drawn from their primitive culture was supported by the remarkable, social system of some of the tribes. Their system of communal marriage, now established by the labours of Howitt and Fison and of Spencer and Gillen, was regarded

as a survival of the most ancient form of marriage. A certain measure of physiological support was given to the current idea of their mental inferiority by the discovery that the head of the Australian black-fellow is exceptionally small. Thus, if the cranial capacity of the average Englishman be taken at 96, that of the Arab will be 89; of the African Negro, 83; of the Chinese, 82; of the Ancient Egyptian, 80; and the Australian aborigine stands, with the Hottentot, on the lowest grade at 75.

The main cause, however, of the prevalent belief in the bad character of the aborigines was the inevitable hostility between them and the early settlers.

Before the advent of the whites, the natives lived, in the main, on game and wild fruits. The white settlers regarded the kangaroo and the wallaby as vermin, and killed them as quickly as possible, to make room for their sheep and cattle. It took the natives some time to understand that, though their food animals might be ruthlessly slaughtered by the newcomers, it was wrong for them to kill a sheep or a cow. The squatters, on the other hand, naturally regarded the stock they had imported at great trouble and expense, as on a different footing from wild game. They had been brought up in England at a time when sheep-stealing was a capital offence; so it is not at all surprising that they treated it as such in Australia, and, where they could do so with impunity, punished the thieves with "back-bush law."

Hence came a bitter feud between the aborigines and some of the squatters, to whom the blacks accordingly displayed the worst traits in their character, and thus delayed the growth of sympathy between the two races. The feud, however, was by no means universal. Many of the settlers sympathised with the aborigines, and treated them humanely, feeding them when they would otherwise have died of famine, and kindly overlooking the occasional killing of a sheep. The aborigines always had warm champions among the colonists; and the colonial Governments, though they made some deplorable mistakes in their native policy, were well intentioned, and did the best they knew. The execution of some white men, who, to avenge the death of some murdered shepherds, lynched the wrong aborigines, showed that in the eyes of the Government of Victoria the lives of the aborigines were as sacred as those of the other inhabitants of the colony.[1] Many of the early

[1] The worst treatment the aborigines received was in Tasmania, where the natives were exterminated while the island was under British military rule. There has been some discussion recently in Britain respecting the treatment of the aborigines in some stations in the back-blocks of Western Australia; but it has been generally overlooked that the evils grew up in the days of the Crown Colony Government, and that when Western Australia was given Responsible Government in 1890 the care of the aborigines was expressly withheld from it. It was not until 1897 that the people of Western Australia were entrusted with this responsibility, and they at once passed an Act for the better protection of the aborigines; and a Bill was introduced in 1904 to amend this Act in accordance with the experience that had been obtained.

The Report by Dr. Roth was written at the instance of the Western Australian Government, in order to secure the full efficiency of its Bill for the better protection of the aborigines.

Australian officials and colonists, such as Sir George Grey, C. J. Latrobe, Governor Eyre, and James Dawson of Camperdown, did their best to protect the aborigines and to describe their better qualities. But their reports were lost in the overwhelming current of hostile description. Moreover, the Australian aborigines, unlike the negroes, had no chance of redeeming their character by personal intercourse with Europe or America. Australia was too far away to be raided for slaves; the natives were of no use as seamen, and the missionary societies, while working in Africa, India, and the remotest islands of the Pacific, did very little in Australia. Hence the idea that the members of the black races were useless savages, and of a distinct species from ourselves—which was once held regarding all of them—gradually became limited to the Australians.

3. THE AUSTRALIANS AS CAUCASIANS

Instead, however, of being more distantly related to us, our cousinship with the Australian black-fellow is closer than with the negro. For, instead of the Australian aborigines being the lowest existing representatives of the human race, they belong to the highest of the primary divisions of mankind. The human race is usually divided into three or four main sections: the Caucasian, the Mongolian, the Negro; to which, perhaps, the Negrito should be added as a fourth division. The Australians must be included in the Caucasians,

and belong to the same race-group as ourselves. This view of their affinities seems to be that now accepted by the majority of anthropologists. The Australians are still sometimes described as negroes; and one popular theory represents the Australian aborigines as a hybrid race, due to the intermarriage of some Caucasian immigrants and a primitive negro or negroid stock. According to this theory, Australia was originally inhabited by the black, woolly-haired Tasmanians, who were destroyed on the mainland by a long and straight-haired Caucasian people, of whom the nearest living allies are the Vedda of Ceylon, some of the hill-tribes of Southern India, and the Hairy Ainu of Japan. It is thus believed, that the present Australian race has been formed by the mixture of the invading Caucasians with the remnant of the Tasmanians whom they supplanted.

This theory, in deference to the high authority of Sir William Flower, who was its leading exponent, I accepted in 1903[1]; but further independent inquiry has compelled me to abandon it. I can find no adequate evidence of Tasmanian intermixture.

[1] *The Geography of Victoria*, pp. 243-4. Mr. R. Lydekker was associated with Sir William Flower in the statement of the hybrid theory of the origin of the Australians, in their joint work on the Mammalia; but on reconsideration of this view, he has been led to abandon it, and to accept them as purely Caucasian—a view which he has expressed in a paper in *Knowledge*, vol. xxiii. (1900), pp. 6-9. The view, advocated by J. Mathew (Eaglehawk & Crow), that the aborigines have an intermixture of Malay blood, fails equally with the theory of the negro or negroid intermixture, owing to the absence of any physical evidence in its support.

(a) PHYSICAL CHARACTERS

As Professor Huxley has so clearly stated, the most striking feature of the Australians is their physical uniformity. Inspection of the magnificent collection of aboriginal skulls in the Adelaide Museum, which has been collected mainly owing to the exertions of Dr. E. C. Stirling, shows a most unusual uniformity in type. If there had been any appreciable intermixture of Tasmanian blood through the appropriation of Tasmanian women by the conquering Caucasians, it should have found expression in the skull-characters. The character of the hair would also have been influenced, and that would have been very easily noticed; and so far I have not been able to hear of any pure-bred Australian with anything like the curly hair of the Tasmanian.

The persistence with which ancestral characters reappear in even remote descendants is a matter of every-day observation. We can recognise the features of the various peoples, who have contributed some share to the British race. The remarkable diversity in the physical features of the Maoris affords an excellent Australasian illustration of this fact. In a small group of Maoris we find several different types, from men barely distinguishable from Japanese[1] to others with the curly hair and coarse features of the Melanesians. The striking uniformity of the Australian aborigines is evidence of their racial purity; and so far I know of

[1] A Maori sailor on one of the steamers on the Wanganui River is continually being mistaken for a Japanese.

no direct evidence for any occurrence of Tasmanian blood in the Australian race. Until such evidence be forthcoming, we may follow those anthropologists, who accept the Australians as pure members of the dark-coloured section of the Caucasian group.

Examination of the Kilalpaninna natives brought ample evidence in support of their Caucasian affinities. The natives have some negroid characteristics. The nose is broad and squat, with the bridge low and the nostrils open ; but the apparent width of both nose and nostrils is artificially exaggerated by the use of a nose-peg—a long, pencil-shaped piece of bone, inserted through the septum of the nose, and projecting for some inches on each side. The prominent jaw is another negroid feature. But the large size of the jaws and of the teeth is probably a secondary variation, due to the hard food which they have had to crush. The most striking character in the Australian face—the depth of the notch above the bridge of the nose and the recession of the eyes—may be another secondary variation, due to the shrinking backward of the eye to escape the glare of the sandy plains. I have been assured by one or two acute observers that it is possible to recognise men, who have been born and have grown up in the Australian plains, by their receding eyes. And if such a change is possible in one generation, natural selection, acting through many generations, may have developed the low bridge and receding eyes of the aborigines.

Our Guide from Kilalpaninna to the Shores of Lake Eyre—Emil Kintalakadi, a Member of the Tirari Tribe, East of Lake Eyre.

An Aboriginee from the Diamantina.

Associated with these characters are others, quite unlike those of the negro. The most striking difference is in the nature of the hair, which in negroes is short and woolly, and very sparsely distributed over the body; whereas the Australian aborigines are among the most hairy of mankind. The hair on the head is straight and long, the beard is full, and the body is sometimes so hirsute that the covering amounts to a thin fur. This down is well shown in the photograph of our Tirari guide. The shape of the head is also different from that of the negro—the forehead is high and the cheek-bones are prominent. Indeed, apart from its colour, the head when seen in profile is sometimes indistinguishable from that of a European.

(b) MENTAL CHARACTERS, RELIGION, AND POLITICAL SYSTEM

I was surprised not only at the marked Caucasian character of the skull and physical features, but at their Caucasian rather than their negro type of mind. With East African negroes, even the best of them, I had always the feeling that they were children, and had to be treated as such. One of them, probably the ablest East African native I have met, remarked to me, "We are children; you are men." But after a few days with our Dieri and Tirari guides, I always felt towards them that they were men and brothers. They had much quiet dignity, and their humour and point of

view with regard to things in general were like those of an intelligent but untrained European.

The ceremonies and corroborees of the Australians are unlike those of the negro. The self-infliction of severe bodily pain resembles the fanaticism of the Indian fakir, and not the merry self-indulgence of the negro. The negro has a remarkable tolerance of pain; but it is not his idea of enjoyment to tie up one of his toes with string, put it into an ants' nest, and wait till the ants have eaten it off.

The statement that the aborigines have no religious belief is quite misleading. They have an intense conviction of immortality—of a future life in a land, which the Dieri think, has a much better water-supply than their own. Some of the tribes that are best known are found to believe in powerful spirits and supernatural beings, who are propitiated by dances or appealed to for help. It is true the Australians have no material idols; for their powerful imaginations render the use of images unnecessary. Howitt, however, has described in one of the corroborees of the Kurnai, the dancing of the medicine-men round a life-sized human figure.

The funeral rites are unusually varied, including burial, cremation, or exposure; but they are always respectful to the dead. The body may be well buried, and the grave made as comfortable as possible, and provided with a set of the tools and the weapons of the deceased, the object being to make the spirit so comfortable in the grave, that it

will not want to roam. Or the body may be lightly buried or placed on a platform in a tree, so that the spirit may roam as freely as it will: its boomerang or its yam-stick is then placed above the grave, ready for the spirit to take on its excursions. Or it may be considered that a decaying corpse is not a good residence for a spirit: hence the body may be burnt, and the ashes placed in some receptacle, so that the spirit is given the fullest freedom it could wish.

Some funeral rites include an act of sacramental cannibalism. A part of the corpse is eaten, usually some of the kidney fat; and it is eaten according to strict rules of precedence. It is an act of respect towards the dead. It is a sacrament inspired by the belief, that the good qualities of the deceased would pass to those who partake of a morsel of his flesh. There is nothing in the funeral rites of the Australians like the contemptuous throwing of a corpse outside a village, to be disposed of by the hyenas, or of cannibalism for mere lust of strange food, as in many African tribes.

Finally, the political system of the aborigines is no mere crude anarchy. Each tribe [1] is ruled

[1] I use the terms "tribe," "class," etc., in their ordinary English sense, which is very indefinite. Much confusion has been introduced into anthropology by giving precise technical meanings indefinite English words, instead of inventing new terms, of whose meaning there could be no dispute. The same English word is sometimes adopted with opposite meanings; thus the word "clan" in American literature is used for a group in which descent is reckoned through the mother, and by Howitt and some other Australian writers for groups where descent is counted through the father.

according to traditional laws, interpreted by a council of the older men of the tribe. Charges of breaking the tribal laws are considered by a meeting of the elders, who weigh the evidence, and, if the offence be proved, decide the punishment. The verdict is often, no doubt, given on evidence that would not be allowed in a British court, and charges of witchcraft are as rife as they were in England a few centuries ago. In these small nomadic communities, the same men have to be judges, jury, and executioners. Nevertheless, this primitive mode of trial is essentially the same, as that from which our jury system has been evolved.

The government of each tribe is very democratic. There is nothing like the arbitrary rule by an irresponsible despot, as in the tribes of the South Sea Islands. Every capable man in the tribe has a voice in its government; and practically each man's influence is proportional to his ability. In the more advanced tribes of Victoria and the southern part of New South Wales, the headmen have more authority than they have among the central tribes. One headman may have more power than the others, and be the actual chief of the tribe; and, according to James Dawson, this chieftainship was hereditary among the aborigines of south-western Victoria, near Camperdown.

4. CLASSIFICATION BY MARRIAGE RULES

One of the most remarkable features of the Australian aborigines is their physical uniformity

all over the continent. Travellers who know them in all the different States say, that it is impossible to distinguish the natives of the different regions by their physical features. It is the same with the languages. Though the number of dialects is legion, they are all constructed on the same grammatical system, and many of the commoner words are similar throughout Australia.

In the absence of physical differences, the multitude of Australian tribes is classified according to the marriage customs and the ceremonial rites.

Howitt and Spencer and Gillen believe, that the occupation of Australia by the aborigines took place along three main lines. One stream of immigrants travelled down the eastern coast, and these people knocked out two of their front teeth; a second stream followed the western flanks of the Queensland Highlands, and then worked south-westward down the rivers which flow on to the central plains. The members of the third stream of immigration travelled into the middle of the continent, along the plateau now crossed by the Overland Telegraph Line. Some of them probably wandered westward; but the course of migration in Western Australia is not yet determined.

The Dieri and their allied tribes of Lake Eyre no doubt came down the middle of the three lines; for they do not regularly knock out a front tooth like the eastern tribes, and they have a more primitive social system than the tribes, such as the Arunta, who spread over the central plateau.

The most striking characteristic of the Dieri and their allied tribes around Lake Eyre is the survival among them of "group-marriage" and of the Australian system of marriage taboo in its simplest form. Individual marriage, except in polygamous and polyandrous communities, is the union of two individuals; but group-marriage is a system, in which a group of men marry a group of women, every woman in the group becoming the wife of every man in the group. This communistic form of marriage was in vogue in Britain; but the system has long since disappeared from Europe, and the best established, surviving cases occur in Central Australia.

This group-marriage may have been noted by the early settlers; and as they were better sheep-breeders than anthropologists, they may have based on it their belief that the aborigines indulged in promiscuous sexual intercourse, like some of the lower animals. But the Australian aborigines have a well-established, definite marriage system, and they enforce its rules with greater severity than that with which any civilised state punishes infringements of its moral code; for sexual intercourse between people too near of kin is punishable by death.

5. EXOGAMY: (*a*) ITS PRINCIPLE

The main principle that underlies the aboriginal marriage system is that of exogamy, according to

which no one may marry a member of his own group. The rules by which this principle is put in practice are variable, and often so complex that the aborigines could not understand them, if they were as unintelligent as has been represented. In some cases the rules have become unworkable, and have been deliberately set aside, as they had rendered legal marriage impossible.

The simplest type of marriage is the most interesting. To avoid the use of unfamiliar Australian terms, the system may be explained by reference to a hypothetical English community living at the period, when men were beginning to adopt the name of their trade as surnames. In this community there would be two chief groups of trades—the members of the one group supplying the food, and those of the other carrying on the handicrafts. The food-purveyors would take the names of Baker, Fisher, Farmer, Hunter, Butcher, etc. The craftsmen would take the names of Smith, Carpenter, Carter, Taylor, and the arrow-maker, Fletcher. Probably in most cases the trades would be hereditary, as they still are in Indian villages, and as they sometimes are in Australian tribes.[1] Let us suppose that our hypothetical community was very small in numbers, and that it was isolated from the communities nearest to it by natural barriers, that were nearly or quite impassable. The most serious evil that would threaten this community would be the

[1] Howitt, *Native Tribes of South-East Australia*, p. 720.

weakening effect of frequent intermarriage between those too near of kin. If the people were close observers, they would probably soon recognise the disadvantage of close inbreeding. Hence they might be expected, if sufficiently ingenious, to frame rules to prevent this inbreeding, by limiting a man's choice of a wife to one of the women in the village who was least related to him. A man would then know from his boyhood, that it was no use for him to fall in love with his first cousin. The law might, therefore, have been passed that a man of the food-producing section of the tribe could only marry a daughter of a craftsman. The community would be divided into two marriage-castes or classes, and marriage in that community would be exogamous. But this one rule would be insufficient to prevent the marriage of first cousins; for the children of John the Baker and Mary the daughter of the Smith would be cousins of the children of Jane Baker and William Carpenter; and the one rule alone would not prevent their marriage. Hence would follow the further law that a man of one trade could only marry into the family of one particular craft; and that, instead of the children following the same trade as their fathers, they must follow another trade, and marry into the trade allotted thereto. Thus a Mr. Baker could only marry a Miss Smith, and a Miss Fisher could only marry a Mr. Carpenter, and a Mr. Farmer could only marry a Miss Carter, and so on. All

the trade-castes could be arranged in two groups as follows:

Food-purveying Caste		Caste of the Craftsmen
Baker	would marry a	Smith
Fisher	" "	Carpenter
Farmer	" "	Carter
Hunter	" "	Taylor
Butcher	" "	Cartwright

According to Julius Cæsar, the marriage system in Britain at the time of his invasion is that known as "group-marriage," wherein a number of men have a number of wives in common. Where this system is in vogue, there must be great uncertainty as to the fatherhood of the children. The mother is certain, but the father may be doubtful. In such communities it is only natural, that the children should inherit the name and the caste of the mother. Under such conditions the children of a Miss Smith and Mr. Baker would be Smiths, and would belong to the caste of the craftsmen. The children of a Miss Baker who married a Smith would be Bakers, and would belong to the caste of the food-purveyors.

The younger generation of Smiths and Bakers would be first cousins, and as they are of opposite castes they might intermarry if the law stopped here. And this law would not prohibit the marriage of father and daughter, for they would necessarily be in opposite divisions of the clan. To prevent this inbreeding, the laws might go on to decide that the children of a Mr. Baker

who has married a Miss Smith shall be Fishers, and shall only marry Carters. The children of a Mr. Smith who has married a Miss Baker will be Carpenters, and must marry Farmers.

By continuing this set of rules through all the available trades close inbreeding is prevented, so far as the limited number of the community renders possible.

The marriage arrangements of this hypothetical community illustrate the marriage system of the Australian aborigines. They adopt the policy of exogamy. Some of the tribes, as in Victoria, adopt the widespread rule of making a man take a wife from some other locality. But this rule would have been impossible in the hunting "packs" of aborigines in the central deserts; while, owing to the small number of individuals in a tribe, exogamy was especially necessary there. Hence the tribe was divided into sections, and a man in one section had to take a wife from the other section.

(b) THE SYSTEMS OF EXOGAMY IN VOGUE AROUND LAKE EYRE

These exogamous divisions of a tribe are generally known as "phratries,"[1] from the word describing

[1] Frazer objects that this name is not sufficiently descriptive. "Phratry" is adopted by Lang, Cunow, Morgan, Durkheim, etc. Spencer and Gillen call these divisions "moieties"; but the term "moiety," coming from the French *moitié*, like the Italian *meta*, comes from the Latin *medietas*, and is based on *medius*, the middle. It is defined by Webster as "one of two equal parts, the half." The term "moiety" implies a numerical division into halves: moieties should be

groups of citizens in an ancient Greek tribe. The simplest Australian marriage system is when a tribe is divided into two phratries, as among the Dieri of Kilalpaninna, whose marriage rules were worked out by Mr. A. W. Howitt. The Dieri tribe is divided into two phratries—the Matteri and Karari; and these are divided into over twenty sub-divisions, known as "totemic groups." Each totemic group takes its name from an animal or plant, or from some other natural object important to the tribe, such as the wind or red ochre. Each member of the totemic group is given the name of the totem, with which he is held to be intimately connected. Thus in some tribes it is the duty of the members of the emu totem to keep up a sufficient supply of emus, to furnish feathers, eggs, and emu-meat to the members of other totems.

The totems belonging to the Matteri caste include those named after the caterpillar, native cat, cormorant, eagle-hawk, mullet, emu, dingo, kangaroo-rat, and a species of acacia. The chief totems of the Karari caste are named after the rain, kangaroo, carpet-snake, frog, crow, native companion, brush-wallaby, fish-hawk, a bat, red

numerically equal. Phratries might be called "marriage-castes." The term would, of course, not imply that the divisions were either social or religious. But this is one of the cases when, in spite of its unfamiliarity, a technical term may be conveniently adopted. So, following the majority, I accept the term "phratry" for the two primary divisions, and think it justifiable to call the sub-divisions, usually called "classes" and "sub-classes," "sub-phratries." Cunow holds that the sub-divisions are different in nature from the phratries. But Howitt and Fison regard them as essentially of the same nature.

ochre, and various species of insects, small marsupials, and mice.

According to the system of exogamy practised among the Dieri, a Matteri can only marry into one of the Karari totemic groups. A dingo cannot marry an eagle-hawk, but he may marry a frog or a crow or a carpet-snake.

To compensate for this restriction, the system of group-marriage gives every man marital rights over every married woman, of his own generation, in the totemic groups with which he may intermarry. Accordingly, it may be impossible to determine who is the father of any particular child ; the father must belong to one phratry, but the individual man may be indeterminable. As there can be no doubt of the mother, the child inherits the name and phratry of its mother instead of its father.

This arrangement is probably the most archaic of the Australian marriage systems, and it is associated with several primitive characteristics. Thus the Dieri and their allies do not use the returning boomerang; they have the simple, curved boomerang which does not fly back to its thrower and has been known since the times of the ancient Egyptians. The Dieri, again, do not use spears or the spear-thrower ; their ornaments are all very simple, and lack the elaborate decorations of the more specialised tribes. They still practise cannibalism, though only as a religious rite : during funerals some of the fat of the corpse is

eaten by the relations, and the order in which they partake is prescribed by special rules. Their domestic utensils are also simple, consisting of baskets, bags of string made from twisted human hair, and the simplest type of digging-sticks; but in the manufacture of these articles, the Dieri show the usual Australian skill in the utilisation of every available natural product.

The two-phratry plan is adopted by various other tribes in the Lake Eyre region,—including the Tirari, between the Dieri and Lake Eyre; the Wonkonguru of the Diamantina; the Yantuwantu, who extend from the eastern frontier of the Dieri to the border of New South Wales; and the Urabunna or Ngarabunna, who live to the north-west of Lake Eyre, and have been described by Spencer and Gillen. Among the Urabunna we meet with an advance on the Dieri plan, for the marriage is still further restricted, and a man can only marry a member of one particular totem of the opposite phratry. Thus a man of the dingo totem can only marry a woman of the water-hen totem.

The tribes with the two phratries are now all small, and their numbers are steadily dwindling. Gason estimated[1] the number of the Dieri in 1874 at two hundred and thirty, and the tribe now musters only a hundred and fifty souls. The Tirari

[1] S. Gason, *The Dieyerie Tribe of Australian Aborigines*: Adelaide, 1874, p. 11.

are represented by only five survivors, and they are all adults without children.

The old marriage system has completely collapsed. According to Herr Reuther of Kilalpaninna, the natives began to disobey their marriage laws some thirty years ago, as the reduction in their numbers and the disturbance produced by European settlement rendered further observance impossible.

While the eastern part of the Lake Eyre basin is occupied by the people with two phratries, the country to the west and north-west is held by tribes with a more complex organisation. They are now well known, owing to the famous work of Spencer and Gillen, *The Native Tribes of Central Australia*, which has been truly described as "one of the primary documents of anthropology."

Some of the western and northern tribes have a division into two phratries, which are sub-divided into four or eight sub-classes or sub-phratries. Spencer and Gillen have worked out the details of the division of the Arunta. The northern and southern sections of this tribe have different arrangements, and neither section has a name for the two phratries.

The southern Arunta have four sub-phratries—Bulthara, Kumara, Purula, and Panunga—whose relations are shown in the following table from Spencer and Gillen:

A Bulthara	man	marries a	Kumara	woman :	their	children are	Panunga.
„ Kumara	„	„	„ Bulthara	„	„	„	„ Purula.
„ Purula	„	„	„ Panunga	„	„	„	„ Kumara.
„ Panunga	„	„	„ Purula	„	„	„	„ Bulthara.

The northern Arunta have eight sub-phratries, the relations of which are shown in the following table from Spencer and Gillen:

A	Panunga	man	marries a	Purula	woman,	their	children	are Appungerta.
,,	,,	woman	,,	,,	man	,,	,,	,, Kumara.
,,	Bulthara	man	,,	Kumara	woman	,,	,,	,, Uknaria.
,,	,,	woman	,,	,,	man	,,	,,	,, Purula.
,,	Uknaria	man	,,	Ungalla	woman	,,	,,	,, Bulthara.
,,	,,	woman	,,	,,	man	,,	,,	,, Umbitchana.
,,	Appungerta	man	,,	Umbitchana	woman	,,	,,	,, Panunga.
,,	,,	woman	,,	,,	man	,,	,,	,, Ungalla.

The advantages of this specialisation of the exogamous system, is that it lessens still further the chance of intermarriage. The division of a tribe into eight sub-phratries is the most specialised arrangement, and is in all probability the latest in development.

The marriage rules vary indefinitely among the tribes. Among the Kamilaroi members of the same phratry, if they belong to different totems, may marry.[1] In the Arunta, members of the same totem may marry. The totem is inherited sometimes from the mother, as among the Dieri; sometimes from the father; and at others, as among the Arunta, from the spirits that are believed to haunt the place, where the child is supposed to have been conceived. The rules, moreover, are very elastic in their application, in spite of the severity with which unauthorised infringements of them are punished. Both Spencer and Howitt give ample evidence that the rules are

[1] R. H. Mathews, "The Totemic Divisions of Australian Tribes," *Journ. R. Soc. N. S. Wales*, vol. xxxi., p. 161.

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frequently and deliberately modified.[1] They are also temporarily suspended. Thus Mr. Siebert tells me that, as a special reward for a deed of valour, a Dieri was allowed to marry a woman within the prohibited degree of affinity. On certain occasions, as at various corroborees, the whole of the marriage rules may be suspended.

The numerous exceptions and the frequent granting of special privileges tend to establish customs, which gradually acquire the authority of rules; and thus the laws, as Lang remarks, have become intricate enough to "puzzle a mathematician."

(c) THE VALUE OF EXOGAMY

The value of exogamy is clearly its prevention of close interbreeding; but it is uncertain whether the system was adopted for this purpose, or whether the aborigines stumbled on it by a lucky accident. Lang suggests that exogamy may possibly have come from jealousy, the older men compelling the young men to go for wives outside their own family group. But he and J. Mathew both think it most probable, that the exogamous groups were originally different clans which have fused. In some cases the exogamy was certainly local: for example, in the Melbourne tribe, a man was not allowed to take a wife from his own locality, but had to go to the Goulburn; and among the Gourn-

[1] *E.g.* Spencer and Gillen, *Nat. Tribes Centr. Austral.*, pp. 15, 272, 421; and Howitt, *Nat. Tribes S.E. Austral.*, pp. 178, 190, 208, etc.

ditch-mara of South-western Victoria, according to Dawson, a man was not allowed to marry a woman from his mother's tribe, or one who spoke the same dialect as himself; but he might marry his sister-in-law—either his deceased wife's sister or his brother's widow. Howitt, moreover, quotes (*op. cit.*, p. 262) the assertion of an aboriginee of Braidwood (to the south-east of Lake George in New South Wales) that "no man should marry so as to mix the same blood." Again, Mr. Mathews says[1] of the Kamilaroi, "In order to prevent such a close marriage" [of brother and sister on the father's side], "every tribe has strict social customs, founded upon public opinion, which will not tolerate the union of a man with a woman whose blood relationship is considered too near."

This explanation of exogamy cannot be correct if Spencer and Gillen and Roth—three of the best authorities—be right in their view, that the Australian aborigines have no idea that children are the result of sexual intercourse. But this view is difficult of belief, in face of much positive evidence on the other side. The aboriginal idea that children have only a spirit father, and no human father, may be a mere childish make-believe. The aborigines pretend to believe many things, and their pretence is so intense that they, in a sort of way, do believe them. For instance, a man believes that by pointing a bone at an enemy, and then burying it in the ground, the bone will

[1] R. H. Mathews, *Journ. R. Soc. New S. Wales*, vol. xxxi., p. 166.

enter his enemy's body. The victim, feeling himself unwell, calls in a medicine-man, who says that he is suffering from a bone, which some enemy has charmed into him. The medicine-man goes through various performances, and by a sleight-of-hand trick produces from the body of his patient the pointed bone, which he has brought with him for the purpose. Every medicine-man is supposed to have in his body numerous small stones, which he can extract at will. Though the medicine-man probably believes in his power to extract both a pointed bone from a patient and stones from his own body, he always takes care to be provided with a supply of those materials.

The man's power of make-believe is so strong that he does not realise his own imposture. And in the same way the people may believe that children are the result of the reincarnation of spirits, and that a human father is quite unnecessary. But they are not sufficiently foolish to believe that, under normal circumstances, a tribe consisting only of women would have a prolific birth-rate.

6. TOTEMISM AND ITS POSSIBLE ORIGINS

The origin of totemism is more obscure than that of exogamy; and there appears, at present, little prospect of anthropologists agreeing as to its cause.

The totemic groups are no doubt very old; and are probably older than the exogamic phratries. Thus the Dieri explain that the marriage restric-

tions were introduced to suppress licentious intercourse, for which purpose members of the same totemic group were forbidden to marry. This tradition makes totemic groups older than phratries.

The numerous theories as to the origin of these totems may be divided into three classes. According to Spencer and Gillen and Frazer, the object was to make some members of a tribe responsible for a particular item in the food-supply, which they had to increase, by magic ceremonies, for the benefit of the rest of the tribe. They point out that a man may kill his totem, but may not eat it—a custom which Spencer and Gillen found among some of the central tribes. This theory is rejected by other anthropologists, on the ground that, although the totems may be used in some tribes for the purpose of increasing the food-supply, it does not follow that they were created for this purpose. These critics point out that totems exist in tribes living in rich-food countries; that the magic ceremonies are a late development; and that in some parts even of Australia, according to Grey, a man must not kill his own totem.

The theories in the second group are based on the principle, that men become associated in various ways with different animals and plants, and are consequently placed under some limitations in dealing with such totems. This association may have arisen in various ways. Howitt suggests that it came as the result of dreams, in which a man thinks he is connected with some natural object.

A people with so real a belief in spirits may easily connect animals and men, by their acceptance of transmigration. The saying of the Wotjobaluk, of the Wimmera district in western Victoria, that "the life of a bat is the life of a man," shows this idea is held. English children often call themselves by the names of different animals, and retain the names amongst themselves for years; and the aborigines, who are mentally children, may conceivably have adopted totems in the same way.

Professor Haddon's theory also belongs to this group. He suggests that the totems began by particular groups of people living mainly on particular foods, and thus becoming associated with them.

The theories of the third group assert that the members of the different totems were originally members of different clans or tribes who have united. Thus J. Mathew holds that the two totems in Victoria, the Eagle-hawk and Crow, were the particular animals of two distinct aboriginal races, who have now merged by intermarriage. Andrew Lang ridicules the idea that a tribe would be deliberately divided into two sections, such as Eagle-hawks and Crows, or Ravens and Wolves; he thinks the totems arose as nicknames, given by the people of one clan to their neighbours, and that these names became accepted; later on various clans joined forces, and their nicknames persisted as the names of the totemic groups.

7. THE RELATIONS OF THE VICTORIAN ABORIGINES TO THOSE OF LAKE EYRE

The tribes with two phratries appear to have originated in North-eastern Australia, and reached the Lake Eyre basin along the valley of the Diamantina and the Barcoo; the tribes with four and eight sub-phratries appear to have come from the north-west, and to have travelled southward along the line now followed by the Overland Telegraph. The two-phratry people again spread southward from Lake Eyre till they reached the Eyre Peninsula in the south-west, and peopled the plains of Victoria and the eastern uplands of Gippsland.

Though the Victorian natives belong to the same group as the Dieri, they have now very different customs. Their marriage system is exogamous; but the marriage prohibitions have a local and not a social or totemic basis. The gradual passage from the primitive Dieri system to that used in Victoria has been lucidly explained by Dr. Howitt. As the tribes migrated southward from Lake Eyre, they probably moved in small hunting groups, for which we may adopt Mr. Jenk's expressive but uncomplimentary term of "packs." In these packs it would often be impossible for men to get wives of the proper totem. The prevention of intermarriage would, however, be equally effected by the men getting wives from another pack. By the time the natives

had reached Victoria, this method of exogamy had replaced the old totemic system. Thus the Melbourne blacks had to get their wives from the Goulburn; but traces of the former totemic system and group-marriage are still recognisable among the customs of the Victorian aborigines. In the north-west of Victoria, the natives of the Wimmera and those on the shores of Lake Tyrrell are divided into two classes, and have definite totems. But in Central Victoria, the only traces of the two-phratry system is the division of the people into the two groups of Eagle-hawks and Crows. These divisions, however, are no longer phratries within a tribe, but are local tribal divisions. Thus the Melbourne natives were all Eagle-hawks, and the Cranbourne natives were all Crows. Farther east again, in Gippsland, even this trace of the two-phratry system is lost, and the only relic of totemism is the survival of such personal names as "Wombat" and "Sea-salmon."

While this change was taking place in the fundamental organisation of the people, progress in other directions had gone on simultaneously. The most important of these has been the change in the position of women.

In small "packs" communism has its drawbacks, and it is almost inevitable that, little by little, the people should mate in pairs rather than in groups. Although group-marriage may remain in principle, it is practically inevitable, if the men and women are in approximately

equal numbers, that they tend to unite in couples, and that individual marriage should gradually replace group-marriage. A beginning of this system is recognisable among the Dieri, for one of the group-wives is more specially associated with one man. And each man may have the wives of the men of his own group lent to him, as temporary concubines. Lang, in fact, holds that the group-marriage of the Dieri is nothing more than individual marriage, in which the men on occasion exchange wives. One man has special claims on one woman, who is his "nupa," while the other wives of his group are to him "parauru," or accessory wives. This "nupa" system, with its beginning of a higher ideal of marriage, may have resulted from the system of infant betrothal; a boy and a girl are betrothed as infants, and after marriage they have a closer claim on one another than on the other members of the group. By the development of this tendency, group-marriage gradually passes into individual marriage of the patriarchal type, in which the man has concubines in addition to a wife. Further progress leads to full individual marriage.

The natural consequences of this change is the increase in the genealogical importance of the man. So soon as individual marriage is established, there is no difficulty in determining who is the father of a child. Accordingly, the children inherit the phratry and name of the father, instead of those of the mother.

Again, as the local organisation and the influence of the father are established, the simple democracy of the primitive Dieri community is gradually modified. The father has more influence over his sons, as soon as the relationship between them is definitely known; and he keeps that influence over his son's family. Thus the old men of the tribe acquire the position of elders or headmen, and the strongest amongst them, or the head of the largest family, becomes the senior headman, with the authority of headman of the tribe.

Thus may be traced the evolution of the comparatively organised clans of Victoria[1]—with their patriarchal government, their hereditary chiefs, and their local system—from the primitive republican communities of Lake Eyre, who practised group-marriage and sacramental cannibalism, who traced descent through the mother, and amongst whom marriage took place between groups, according to totemic law.

8. ARE THE AUSTRALIAN ABORIGINES THE MOST PRIMITIVE OF MANKIND?

This change in customs from the primitive tribes with two phratries, as the Dieri, who count descent through the mother, to the conditions

[1] I have recently called attention to the complete absence of any satisfactory evidence for the antiquity of man in that state, in most parts of which the gravels have been very extensively worked ("The Antiquity of Man in Victoria," *Proc. R. Soc. Vict.*, New Series, vol. xvii. 1904, pp. 120-147).

found among the Victorian tribes, shows the natural influence of environment on the customs and belief of the people.

The old idea, that the Australian aborigines were the most degraded and barbarous of existing races is one which must be abandoned, when they are included as members of the Caucasian group, for they are then ranked in the highest of the primary divisions of mankind. They are among the most primitive of the existing Caucasians; and it is tempting to regard their primitive customs as having been handed down to them, but little changed, from the time of the early stone-using ancestors of the Caucasian family. Thus according to Barton,[1] "In the Australian aboriginal we have an accurate picture and exemplar of prehistoric man, as he existed in the old world during that period when the reindeer roamed with the mammoth, the great elk, and the aurochs over the plains of Central Europe. We have a type of man older than those pyramid-builders of Egypt, who possessed, in common with him, the secret of the boomerang and the throwing-stick; older than the Chinese, with their still-existing fossilised civilisation, or than the long-extinct Accadians of Mesopotamia, from whom China, in all probability, received it,—a type of man contemporary, in point of development if not of time, with the cave-dwellers of France and Liguria, the oyster- and mussel-eating savages

[1] C. H. Barton, *Outlines of Australian Physiography*, 1895, p. 153.

of the Danish Peninsula, and the still ruder and earlier race, whose primitive spear-heads and chisels of flint are found in the river-gravels of the Thames and the Somme."

Andrew Lang also insists on the low status of the aborigines. He says "they are, though our contemporaries, infinitely beneath the status in culture of palæolithic man of the mammoth and reindeer period."[1] He places the Australians below the men of the older stone age, because they had domesticated the ox, the horse, and the pig, which the Australian had no chance of attempting. Lang also instances their inferiority to the European palæolithic people in matters of clothes, which the Australian could well do without. But Lang then points out that we cannot expect the aborigines to have retained their primitive culture. He urges[2] that, "backward and conservative as the Australians are, we must not expect to find among them, with their highly complex customary laws, anything like the first beginnings of social regulations."

It seems to me very doubtful whether the Australian aborigines are as archaic as they have been so often represented. The tribal system and their physical characters are more likely to be highly specialised adaptations to the desert conditions under which most of the aborigines have lived for so long. Their spare muscular

[1] A. Lang, *Social Origins*, 1903, p. 4.
[2] *Ibid.*, p. 6.

forms enable them to withstand drought and enforced fasts. Their unrivalled skill in tracking and their remarkable powers of observation have come from the efforts of many generations, in their anxious quest for their scanty, uncertain food.

Their marriage systems are adapted for the life of small, hunting packs, to whom nomadic existence is indispensable, and concentration of population is impossible.

The physical, mental, and political development of the aborigines is dominated by adaptation to the peculiar conditions of the arid regions of Australia. The specialisation to suit the exacting conditions of his environment may have left but little of the primeval man.

The detailed accounts of Spencer and Gillen, and Howitt and Roth, show that, in spite of their physical uniformity, the rites and beliefs of the aborigines are remarkably varied. This fact is only natural in the case of small groups of people who have no written documents to fix their beliefs, and comparatively limited intercourse with their neighbours. The evidence of African anthropology, shows that people living under such conditions are in state of a constant and rapid flux. The variety of aboriginal rites and ceremonies in Australia is so great, that it would be very difficult to select the original and archaic forms, if indeed, any such have survived. Even the two most primitive characteristics—female descent and the simple, twofold division of the tribe for

marriage purposes—may have been acquired by the few tribes that have them, in consequence of the impoverishing environment. The Dieri may have acquired these customs by secondary adaptation, and not by unchanged inheritance.

When the *Challenger* Expedition made the first extensive collections from the abyssal depths of the great oceans, the primitive-looking animals were regarded as comparatively unchanged survivals from earlier geological times. But as these forms were more closely studied, the aspects that suggested their supposed antiquity were found to be deceptive. Instead of being comparatively unchanged descendants of the animals of the Chalk or Carboniferous periods, they proved to be modern developments with an old-time aspect, due to their having been driven by competition into the zones of the sea unfavourable to life. They were primitoid, not primitive. So with the Australian aborigines. Their lot has fallen in a land where there are no native animals worth domesticating—no race could have done much with the kangaroo or the tiger-snake; where agriculture is especially uncertain, and where there are few edible plants that could be improved by cultivation, except in the Queensland forests; and they were avoided by the aborigines, as they preferred the open, sunlit plains.

Similar causes have remoulded the physical features of the aborigines. They resemble negroes and apes in the parts of the body, most likely to

vary in adaptation to conditions of life, such as the jaws, teeth, and palate, the curvature of the spine, and the development of the muscles of the legs. The jaw and teeth are perhaps of all parts of the body the most easily altered by changes of habit; the pointed prognathic skull of the greyhound and the blunt, shortened, flattened skull of the bull-dog are both modern developments from the primitive dog; and the irregular, overcrowded teeth of the Englishman and the American, due to the small size of the jaw, illustrate the ease with which these structures change.

Hair, however, is much less liable to change; as is shown by the reappearance of curliness in the hair, often the last surviving sign of negro blood. Environment does not affect the hair so readily and directly as the jaws. The long hair and full beard of the Australian are essentially Caucasian, and in that respect he is utterly unlike the negro. Primitive man is not likely to have had hair of the Australian type, for he probably had the close fur of anthropoid apes. He also, like the negro, would have had the retreating forehead of the ape, and not the high, straight forehead—so European in aspect—of the Australian aborigines.

It is therefore likely that the Australian aboriginee is further removed from the primitive ancestor of man than is the negro, and that he belongs to the highest primary division of mankind. It is most improbable that man first developed in Australia. He must first have appeared

in a land inhabited by the anthropoid apes. Wherever he developed, it was not in Australia. He must have gone there from some other land. "Our progenitors," says Darwin,[1] "inhabited the Old World; but not Australia nor any oceanic island, as we may infer from the laws of geographical distribution. . . . It is somewhat more probable that our early progenitors lived on the African Continent than elsewhere." Moreover, the geographical conditions of Australia are very different from those of any other land, where man is likely to have developed. So when he wandered to Australia, he must have adapted himself and his ways to the altered conditions of his new home, and we should not expect to find man in Australia in his primitive condition. It is possible that he is nearer primitive man than any other living race; but even this does not seem to be likely.

His most primitive character—his ignorance of the use of metals—he shares with people, who are usually regarded as among the most advanced of savage races, such as the Maoris of New Zealand. The rest of his physical and mental characteristics, seem like highly specialised adaptations to the abnormal, geographical conditions under which he lives.

[1] C. Darwin, *Descent of Man*, 2nd edit., p. 155.

CHAPTER XIII

A CORROBOREE AT THE PEAK

"Don't be croth with uth poor vagabondth. People mutht be amuthed. They can't be alwayth a-learning, nor yet they can't be alwayth a-working—they ain't made for it. You *mutht* have uth. Thquire, do the withe thing and the kind thing too, and make the betht of uth—not the wurtht!"

Mr. Sleary, in "Hard Times."
CHARLES DICKENS.

THE word "corroboree" has been adopted, from the extinct language of the tribe that lived around Port Jackson, to describe an assemblage of the aborigines for songs, dances, or tribal conferences. Such gatherings occur among most races, but they probably play a larger part in the lives of the primitive aborigines of Australia, than among any other people. Corroborees are the chief incidents that break the usual monotony of their days. These gatherings are their chief amusement, providing the opportunity for social festivities, gymnastic displays, and musical competitions. Performances at some of the corroborees are the only religious ritual which our aborigines possess; for though it is sometimes denied that our godless heathen have any religion, they certainly, at some corroborees, appeal to powers not themselves,

which they believe can help or hinder them. Moreover, the secret rites of the aboriginal freemasonry are performed and explained at corroborees; and the decisions that serve as native justice, and the sentences of punishment, for the infringement of tribal laws, are determined at these gatherings.

The corroborees thus vary in their functions—some are sacred and secret, others are mere social entertainments. As Sir Thomas Mitchell wrote in 1838, "There can be little doubt but that the corrobory is the medium through which the delights of poetry and the drama are enjoyed, in a limited degree, even by these primitive savages of New Holland."[1]

We were all anxious to see a corroboree, for these night dances are described as weirdly picturesque, and they are every year becoming rarer and more limited in their distribution. We felt, moreover, the interest of ceremonies that may have been handed down by tradition, by this supposed, oldest of human races, from a remote antiquity. I was especially interested in the chance of obtaining some first-hand evidence, as to the variability of these performances. Every corroboree that is carefully described throws light on the history of these ceremonies, by showing the rate at which they change as they pass from tribe to tribe, and thus giving some basis for an idea of their antiquity.

[1] T. L. Mitchell, *Three Expeditions into Eastern Australia*, vol. ii. (1838), p. 5.

THE TJI-TJI-NGALLA CORROBOREE, AS PERFORMED AT KILALPANINNA.

From a Photograph lent by Herr Siebert.

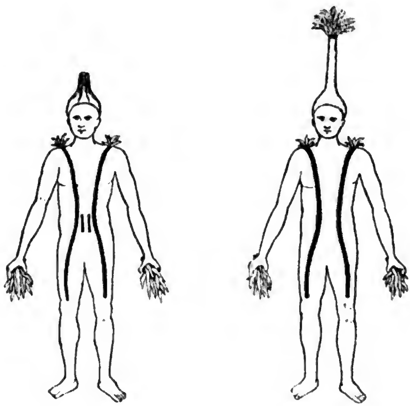
The corroborees are always held at night, and they are said to be usually held on moonless nights—although in Tasmania nights of full moon were selected for the tribal dances, probably because of the light. The Tji-tji-ngalla corroboree, which it was our good luck to see at the Peak, was apparently held at any period of the month. The place selected for the performance was at some distance from the permanent settlement of the aborigines, in a stretch of smooth, soft loam, by one of the water-holes of the Neales River.

A temporary camp had been pitched near the corroboree ground, and there we waited till shortly after sundown. Suddenly a tremor of excitement ran through the people, as an aboriginee, his face dyed with red ochre and his head decorated with a plume of white feathers, pranced into the camp. The man was dressed in a shirt, which would have been more suitable to a mixed assemblage, if it had been a few inches longer; and he was armed with a couple of red boomerangs, which he struck together, as he chanted to us a summons to follow him to the ceremony. He led the aborigines out of camp; so we mounted our camels and followed through the scrub to a cleared space, some two acres in extent, beside a water-hole. There, we tied our camels to the trees, and sat on the ground behind the rest of the audience. It consisted of about sixty men and women, the latter taking the back places. Most of the spectators were provided with a pair of red, corroboree

boomerangs, which they struck together in time with their songs. A little to our right, between us and the point where the sun had set, was a thick lignum-bush, behind which was a small native hut, used by the performers as a dressing- or retiring-room. The audience began to sing and clash their boomerangs together; and, apparently in answer to the summons, one of the performers came out of the hut, and strutted forward, till he faced the audience. The man wore a conical helmet, which tapered above to a stalk, a foot or so in length, ending in a tuft of black emu feathers. His body was decorated with two curved stripes of red paint; these red bands were dotted over with white down, and they extended from the shoulders to the knees. Each colour-band ended above in a tuft of box-leaves tied on the shoulder; and each dancer carried in either hand a tuft of the same leaves, which rattled as he shook them in the dance. The dance began by the performer covering his face with the box-leaves; he then stamped slowly and heavily with his feet, keeping time with the song of the spectators. After a couple of minutes' slow stamping, he supplemented this movement by jerking his arms out to their full length, level with his shoulders, and then back again to cover his face. He kept up this dance for about three minutes, gradually increasing the speed and violence of his stamping; he paced backwards about ten feet, bent forward with a low bow to the audience,

and withdrew. He was succeeded in turn by each of his five comrades, who practically repeated the same dance and wore nearly the same costume.

The principal variations in the dress of the men were as follows:—Four of them had helmets, exactly the same as that of the first performer;



but two of them had low, broad, featherless stumps above their helmets, which were marked with vertical strips of black and white. Some of the men had pubic tassels and others had not. All had big tufts of box-leaves tied on to the small of the back. Each man had a pair of colour-bands stretching from the shoulders to the knees. One had, in addition, two vertical bars, each about

four inches in length, along the breast. In most cases, the colour-bands followed the general curves of the body, curving inward at the waist, outward at the thighs, and then inward again at the knees. But in some cases the curve was reversed, the bands being farthest apart at the waist. I took careful note of the decorations, thinking at first that they might have some symbolic meaning, or that they might be conventional representations of natural objects, such as Professor Haddon has traced in the designs, used by the natives of New Guinea. But apparently they had no special signification; the costumes were all of the same general character, and the variations seemed due to caprice, to individual taste, or to accident. So far as I could learn from the natives, the decorations were ornamental and not symbolic. The same type of helmet is shown by Professor Spencer and Mr. Gillen's photographs, to be used in a very different corroboree of the Arunta tribe.[1]

After the performers had appeared singly, they all came out together, and marched up and down the dancing-path. They formed up in line, facing the audience, and went through the same dance, all stamping together, jerking out their arms at the same time, and then bringing their hands back again, until the box-tufts covered their faces. We noticed that, though they kept step very well, as far as time was concerned, it did not matter

[1] Spencer aud Gillen, *Native Tribes of Northern Australia*, p. 468.

which foot was used. Some used the right foot while others used the left, in a manner no British drill-sergeant or French dancing-master would have tolerated. After dancing for five minutes together, they withdrew to their hut; then, after a short rest, they returned, and marched in single file, round and round in front of the audience. They moved slowly, but they stamped with such violence on the ground, that the movement must have been very fatiguing. When the men were exhausted, they withdrew to the hut, and the first act of the corroboree was at an end.

The music was supplied by the spectators. They sang several songs, and I took down the refrains most often repeated. The song, which summoned one of the performers to come forward and dance, was, as nearly as I could catch it—

Ya ma ta ra abadai,
Ya ma ta ra abadai.

During the dances the most frequent song was—

Ya nowa dowa, dowa, dowa;

while another familiar verse consisted of—

Wai-ja, wai-ja, etc.

During an interval in the performance, I asked the best English-speaking aboriginee what these songs meant. I thought the words were probably only jabber, from the frequent, and apparently irregular, variations. The native told me that the

words originally had a meaning; but that no one now knew what it was. They were, he said, old-time songs, and no living man knew the meaning of the words. I felt half inclined to think that the explanation of one song, was that some Queensland aboriginee had been to a Brisbane music-hall, and heard "Ta-ra-ra-boom-de-ay," and that we had been listening to a distorted echo of that catching refrain.

We waited for some time in the hope, that we should witness the second part. But the performers and audience had withdrawn to their suppers; and as neither our jeers nor entreaties would make them begin, until after the regulation interval, we could not stop for the second act. We were greatly interested in the corroboree, though we were not able to get much definite information about it from the natives. But I took detailed notes, in the hope of identifying the corroboree with those recorded from Queensland, and of seeing if our informants were right in telling us that it had come thence. I also hoped to discover what measure of change had taken place in the performance during its passage, and whether the aborigines can transmit strange words and songs with as great accuracy, as is sometimes reported.

On sending some notes about the corroboree to Herr Siebert, he recognised it as the same performance, as one that had shortly before reached the Dieri at Kilalpaninna, and could be identified

as "the Molonga corroboree" of Queensland. The first part of the history of this corroboree, and a full description of it, as practised in Northern Queensland, has been given by Dr. W. E. Roth.[1]

According to Dr. Roth, this corroboree first appeared among the Workia, a tribe living at the head-waters of the Georgina in Queensland and in the north-east of South Australia; but whether they invented it or not is unknown. It travelled from them to Camooweal and Lake Nash, and thence to Carandotta, whither it was taken by the Yarroinga. It was performed in Carandotta in 1893. It was carried thence westward, to the Toko Ranges, and down the Mulligan River; eastward, along the Liechardt-Selwyn Ranges, across the Buckingham Downs to Cloncurry; and southward as far as Roxburgh and Glen Ormiston, which it reached in 1894: by the next year it had spread still farther south, to Boulia and Herbert Downs. From Boulia, it was carried down the Georgina towards the Lower Diamantina, and it spread along the route across Spring Vale to the Middle Diamantina, where it was met with at the beginning of 1896. This is the farthest south, which the corroboree had reached at the time of the publication of Dr. Roth's account. The words of the songs appear to have been understood by the natives of the far north, who first sang them; but by the time they had

[1] Walter E. Roth, *Ethnological Studies among the North-west-central Queensland Aborigines*, Brisbane, 1897, pp. 117-8, 120-5, pl. 16.

reached Roxburgh, the words were unintelligible to the individuals who used them.

It appears, then, that it has taken six years for the corroboree to get from the Middle Diamantina to the Lower Diamantina, and across the Lake Eyre basin to the Peak.[1] It has travelled more slowly than it did at first, and undergone greater changes. Dr. Roth found that in Queensland the corroboree was passed from tribe to tribe, with but insignificant alterations. He found that the words were the same, when taken down phonetically, from people speaking different languages and living a hundred miles apart. The costumes too were practically identical. In the passage from Queensland to the Peak, however, both words and costumes have undergone great changes, though the essential part of the corroboree is the same. It is still a five-nights' performance; the audience are summoned by the same Molonga; the performers retire to the same dome-shaped wurley, which was built on the right-hand side of the audience, and which was apparently to be destroyed by fire at the close of the performance. According to Dr. Roth's report, the fifth night's performance consisted, in the first place, of the

[1] The same corroboree has been seen by Spencer and Gillen among the Arunta tribe, apparently within a few months of the time that we saw it at the Peak. They have published two photographs of it (*Northern T. C. A.*, pp. 719-20), which show that there were several differences from the decorations and dances used by the natives at the Peak. It has also been seen at Kilalpaninna by Herr O. Siebert, from whom I have received two photographs, showing some slight differences from the Peak costumes.

appearance of Molonga, the incarnation of a mischievous evil-doer, who may be compared to the European conception of a devil. This Molonga carried a long spear, tipped with feathers, with some enormous white feathers stuck into his hair; his body was ornamented from the shoulders to the waist with vertical stripes of red ochre, separated by white lines. He carried two tufts of box-leaves, hanging from a waist-band at the small of his back.

Our Molonga had his body and face dyed with red ochre, and he wore a shirt; whereas, in the Northern Queensland performance, the Molonga's only dress was a waist-band made of hair. Our other performers combined, on a single occasion, the types of costume and ornamentation which were originally divided over several nights. The helmet, with its long stalk, was only worn in the Northern Queensland ceremonies by the performers during the first evening, and the stalk was shorter; while on the fifth night they all had the low, conical helmets with vertical stripes, which we saw worn by two performers. Our performers had no tufts of leaves tied to their anklets, but they had instead similar tufts fastened upon their shoulders. The single tuft of leaves hanging down the back of the Peak natives was a modification of the original design of two large tufts, hanging down, on either side of the waist.

The leading feature in the ornamentation of the performers in both localities was a curved, vertical red band on each side of the body. As used in

Northern Queensland, the two colour-bands met in the middle line of the body; but, as adopted by the aborigines of the Peak, the two bands were quite separate. The performers in the fifth night's corroboree in Queensland had the vertical colour-band divided into short divisions by white tufts of down; but this has been lost among the natives of the Peak, as well as the horizontal colour-band shown in Dr. Roth's drawings.

The songs, too, appear to have changed; the first is reported by Dr. Roth as follows:

Pil-il-a-roo-la-wot-ya-rum-brin-a

Then:

Pā-ŭm-pā-ŭm-bĭ-mĕt-yĕ-kō-lā-ră
Gā-lā-wēr-nă wŏt yă chā-ră-nă
Gā-lā-wēr-nă wŏt-yă-wŏt-yă-rā.

Comparison with the words previously reported show that, though there may be certain faint traces of resemblance, the differences are so great, that it is not surprising that the meaning of the words has been lost. As the songs are only passed on by ear, it is natural that they should undergo radical changes. Dr. Roth has quoted the same song as used by tribes living only ninety miles apart, viz. at Glen Ormiston and Boulia. The first two lines are as follows:

Mŭn-nŭn-kō-bī lă-kŭn-kŭn-gŏr-īl-ă,

as sung at Glen Ormiston;

Mŭn-nŭn-kō-pī-ō-lă,

as sung at Boulia.

As such changes take place within ninety miles,

and within a short time, it is not surprising that in the long migration from Queensland to the western side of Lake Eyre, the sounds have changed until they are practically unrecognisable.

Languages which are not fixed by writing change with a rapidity, that we are apt to underestimate. Even the conservative influence of written literature will not prevent a language developing many local dialects, if the majority of the people who use it, only speak and cannot write it. Thus the comparatively modern language, Swahili, in spite of being written, has already acquired a different dialect in each of the East African coast towns.[1]

The corroboree, therefore, helps to show how rapid are the changes that take place in aboriginal songs and ceremonies, and how the meaning of a song may leak away as it is passed by ear, from tribe to tribe among these people. The changes wrought in a six-years' migration may be so complete, that the singers of a new song may believe that it is of vast antiquity and written in the extinct language of their remote ancestors.

[1] According to so excellent an authority as Sir Charles Eliot, even the quarters of one town have developed special peculiarities in the language of their own.

CHAPTER XIV

GEOGRAPHY AND MYTHS

Truth hath always a fast bottom.

Italian Proverb.

THE folklore of primitive peoples consists of two classes of story—the fable and the myth. Fables have a moral purpose, and are, as the children say, "made up" for their benefit. Myths, on the other hand, are natural growths; they arise in the attempt to explain natural phenomena, or linger as the shadowy reminiscences of historical incidents. The Hare and the Tortoise is a didactic fable that was doubtless invented to teach the value of perseverance. The myths of Thor and Jupiter and their thunderbolts are efforts to explain the mysteries of meteors and of the thunderstorm. The legends of King Arthur and the Round Table are myths founded on historical traditions.

The folklore of the Australian aborigines includes representatives of these different types. The fable that spirit-beings kill young men, who eat food that is forbidden to them, was probably taught by the elders to secure obedience to tribal

rules, which gave them the monopoly of certain food. The story, how the wily turkey-buzzard persuaded the innocent emu to cut off her wings, was doubtless invented to explain the absence of wings in that bird, and perhaps also to teach the disadvantages of credulity. The statement that the Pleiades and the Magellanic clouds were people who had gone to heaven, owing to their improper dealings with fire, and the Dieri belief that the Milky Way is the river of the sky, are obvious attempts to explain the problems of Nature.

The classes of Australian myths, which may be regarded as distorted history, are of the most importance to the geographer and the ethnologist; for they give valuable suggestions, as to the former conditions of Australia and the distribution of the Australian people. For instance, the legend of the wild men, who were said to exist in Wilson's Promontory, the Hoddle Range, and the Bass Range is interpreted by Mathew [1] as a probable indication of the survival of some members of the Tasmanian race, in the wild recesses of Southern Gippsland.

We therefore naturally turn to the folklore of the Australian aborigines for evidence, as to the condition of Central Australia in the early part of its human occupation, and for information regarding the migrations and origin of the people. It was in answer to my inquiry of Dr. Howitt,

[1] J. Mathew, *Eagle-hawk and Crow*, p. 19.

whether the natives of Lake Eyre had any stories about the former size of the lake, that he told me the Kadimakara legend, which was the direct cause of our journey. As a general rule, where stories of giants and dragons are assigned to precise localities, they are founded on the occurrence of fossil bones. For instance, the legends of the former existence of terrible monsters on the Island of Samos gave the clue, that led Dr. Forsyth Major to the discovery of the rich deposits of mammal bones, for which the island is now chiefly famous. The legend of Sindbad the Sailor's roc was no doubt founded on the gigantic eggs of the extinct æpyornis, which are found in Madagascar. I felt assured that, if only we could reach the places where the aborigines held corroborees to the spirits of the Kadimakara, we should find a rich deposit of extinct animal remains.[1]

The geographical interest of the Kadimakara legend is due to its indications, that the ancestors of the Australian aborigines lived in a forest country, covered with the thick roof of vegetation, which is the most striking feature of a tropical forest. It was more probable that the people had moved southward from the tropics, than that the tropical forest should have existed in Central Australia. We cannot explain the forest-roof of

[1] While my inquiries were being made, this view was confirmed by the discovery of fossil bones by Mr. H. Y. L. Brown on Cooper's Creek. Bones had previously been found by Mr. Brown on the Diamantina.

the legend by any exuberance of the gum-trees; for their foliage always hangs loose and vertical, and could not form the thick, felted floor of vegetation, which is reported in the legends, and which exists in Central Africa. I therefore made further inquiries in the Lake Eyre district as to legends, which would throw light on the question, whether the Kadimakara story originated there, or whether it was of foreign origin. The myths which are quoted in this chapter, not only serve as examples of Central Australian folklore, but throw light on the former, geographical condition of the country.

Most anthropologists agree that the Australian aborigines came from the north, though they may differ as to the exact route of the migration. Some authorities, such as Eyre, state that the aborigines came from the north-west; others, such as Mathew, believe that they entered Australia on the north-eastern coast. Others, such as Howitt, say that the two-class tribe came from the north-east, and that the more specialised four-class and eight-class tribes came from the Northern Territory of South Australia, along the plateau now followed by the Overland Telegraph Line. All agree, however, that the people entered Central Australia from the north.

Nevertheless, both the missionaries at Kilalpaninna, Herr Reuther and Herr Siebert, say that the legends of the Dieri affirm, that the tribe entered that country from the south. Thus, when

the whites entered the Lake Eyre basin, they were warmly welcomed, as they were regarded as the reincarnation of former aborigines. This belief implies the death and burial of the ancestors of the Dieri, to the south of their present homes. Further support is given to this view by the fact, that the Dieri bury their dead on the southern side of their camps. It is a frequent rule for people to bury the dead on the side of their settlement, nearest the land from which they came, and the body is generally placed facing the same direction. A song that I once heard at an Irish wake in the backwoods of Canada—

> Lay me at length with my face unto the West,
> Looking toward the land I ever loved best—

illustrates, with its geographical "bull," the survival of this sentiment. The Uganda rule, that a new king must enter the country across the Nile the day before his coronation, because the founder of the kingdom entered the country by that route, illustrates another way in which native customs point to the former home of a tribe.

The most definite legend suggesting the southern origin of the Lake Eyre people is that of the origin of the Arunta. The story was told me by Mr. Kempe of the Peak Station.

Long ago, it is said, the Arunta country was uninhabited, and there were no people living nearer to it than the tribe of the Kuyuni near Hergott. A Kuyuni girl was betrothed by her parents to

a man she loathed; rather than submit to the marriage she fled northward, and after a long journey (it is more than a hundred and fifty miles) she found a cave on Mount Todlery. There she lived, absolutely alone, for many years, collecting wild plants and animals for food. At length, although she had not seen a man for years, she found herself with child. A boy was born to her, and the two lived in happiness in the cave till he had grown to be a man. Then he was suddenly stricken with illness, and died. His mother buried him, and wept over the grave. Her laments were answered by his return to life on the third day. After his resurrection he journeyed north-westward to the Arunta country, where he lived for many years, and had many children. Their children are the tribe of the Arunta.

This legend definitely asserts the southern origin of the Arunta. But this myth only necessarily implies a northerly movement, for a comparatively short distance. It is quite consistent with the main migration having been from the north, while offshoots spread backwards, north-west, from the main line.[1] The legend itself certainly suggests a northern and an Asiatic origin. It combines the elements of the story of the miraculous conception of the virgin and the death and resurrection on the third day of her only son, who

[1] Spencer and Gillen, *Native Tribes of Central Australia*, pp. 387-447, have shown the irregular wanderings of these tribes, by an interesting collection of Arunta traditions.

subsequently founded a new people. The legend includes features which are essential elements in the religion of the Aryans. The idea of conception by a virgin is consistent with the aboriginal fancy, that children are the reincarnation of spirits, who enter the mother when she is asleep. The resurrection part of the story may perhaps, be a modern introduction due to missionary influence. Mr. Kempe, however, emphatically rejected my suggestion of the recent origin of any part of the story.

The burial of the people on the southern side of the camps, and the expected appearance of the re-embodied ancestors from the south, may merely indicate the peopling of the Lake Eyre country, by tribes returning northward from the highlands, immediately to the south. It may not prove even so much; for it may only result from a belief, that the spirit-country lay to the south. According to Herr Reuther, the Dieri believe that each individual consists of three elements—the body, soul, and spirit. When any one is dying, the soul leaves the body, and watches it till the moment of death, when the spirit also leaves. The soul then goes to Palkarakani by Lake Hope, and thence to Mitamaralje, which may be regarded as the native heaven. The bodies are buried toward the south, because that way lies the "Land of Life," the Tabiamickie, whence the body comes back in white form.

That the original home of the Lake Eyre aborigines was to the north of their present country is indicated by several definite and important myths. The Dieri, according to Herr Siebert, attribute the origin of their customs to a northern source. They say their circumcisional rites came from the Gulf of Carpentaria. Two boys, named Kaiari and Kariwillpa-Jelu,[1] who are now canonised by inclusion among the legendary ancestors known as Mura-Mura, were throwing their boomerangs, in play, on the shore of the northern gulf. One of the boomerangs fell into the sea, and its owner went in after it; he was surprised to see that the weapon continued to whirl through the water. It swept back to him, and in one sweep effected circumcision. He called his brother to come into the sea, and the boomerang circumcised him in a like manner. Both boys felt ashamed of their condition, but they thought it best to put a bold front on the matter. So they composed a song in honour of the incident, and went southward through the country holding corroborees, at which they circumcised all the men. The rite at this date was done by fire, and the operation was so terrible, that one man died out of every two that were subjected to it. Hence, the subsequent discovery of circumcision by stone was, perhaps, the most important event in the history of the Australian aborigines.

[1] Kaiari means *creek*, Kariwillpa, *sky*, Jelu, *till*: the names mean "One creek till up to the sky."

This myth is of value, because evidence about religious rites is specially significant; and it positively asserts the northern origin of the religious rites of the tribe.

A variant of this legend, told by the Dieri, describes this incident as having happened locally at Lake Hope, which is on Cooper's Creek, to the east of the Dieri country. This change in the story is probably due to the habit people have of carrying their legends with them, and ascribing them to some locality in their new home.

Wherever the ancestors of the Dieri originally came from, we have our choice between the alternatives, that the myth of the Kadimakara may have been brought with them, or that it may be of local origin and a reflection of the former condition of Central Australia. The chances are that it is partly local and partly foreign. The legends of the Kadimakara are very mixed. They obviously relate to, at least, two distinct animals. One of these lives in pools and attacks people who go near them. The commotion of a whirlwind, sweeping across a sheet of water, is explained as due to the presence of a Kadimakara swimming beneath the surface. These Kadimakara are still believed to have magic power. Thus, the blindness of a boy now living at the station at Cowarie is explained, as due to a Kadimakara having breathed over him, when he went to the edge of a pool on the Diamantina.

The stories of this type of Kadimakara may be based upon the crocodile; for that the crocodile once swarmed in the rivers of Lake Eyre is shown by the abundance of their fossil remains, that we collected there. But as crocodiles still live in the rivers of Queensland, the legend may easily have been invented there, and carried southward.

The second type of Kadimakara was a big, heavy land animal, with a single horn on its forehead. This description suggests the diprotodon, which was a huge animal about as big as a rhinoceros, and provided with a large projection on the nasal bones; but, in life, this projection probably supported a fleshy trunk like that of a tapir, and not a horn. So that the imaginary horn of the Kadimakara is most likely an imported idea. Unicorns are familiar in the folklore of most peoples, and legends based on the Indian rhinoceros are not impossible among a people, who are connected with the hill tribes of India, and have some legends relating to miraculous conception and resurrection.

That the present Kadimakara legend of the Dieri is not indigenous, is rendered probable by its occurrence in a different form among the natives of the Peak. For their version I am indebted to Mr. Kempe. According to this story, the Arunta country was covered by a sky-land in which lived many people, who at times descended to the earth to play during the daytime, by climbing down a long pole. They were under

orders always to return to their sky-land at night, as it would be dangerous to remain below. The guardian of the sky-land always locked the entrance to the top of the pole, when the people had all come home. Two of them, however, resolved to disobey the instructions. One evening, when their companions returned, they hid themselves under the leaves of a big water-lily. They kept there until it was so dark, that they could no longer be seen from above, when they left their hiding-place and spent the rest of the night in play. The guardian was so angry that he refused to let any more people go down below, and communication between the sky-land and the earth was thus for ever broken.

This story is obviously derived from the same source as the Dieri legend of the Kadimakara, and it shows some resemblance to the familiar legend of "Jack and the Beanstalk." The difference between the sky-land stories, of the opposite shores of Lake Eyre, are striking. Among the Arunta it was men, instead of animals, who went up and down between the earth and the sky-land, and the privilege was withdrawn by the disobedience of two of the people; but there is the same essential idea of a sky-country, to which communication was formerly possible by climbing up a tree or pole. This is probably the essential part of the original legend, and the differences between the two myths, as now told at the Peak and by the Dieri, are probably of later growth. The

Peak story resembles the Eden of the Aryans. The Dieri have modified the story to explain the occurrence of the great bones in the rivers of their country. Further support to this conclusion is given by the efforts of the Dieri to justify their belief in such a sky-land. They say there must be such a land, because they find sand in the nests of the birds, high up in the trees. This argument is feeble, even for an Australian aboriginee. The people are right in saying that the birds do not carry up the sand; but the wind, as every Dieri knows, lifts sand up to a greater height than the tallest tree in their country.

Some of the legends give stronger evidence that the geographical conditions of Lake Eyre have not changed fundamentally since the human occupation of the district. For these legends describe the country, as having had its present physical characters during the time of those legendary ancestors of the aborigines, the Mura-Mura.

One Dieri tale says that the totem animals were created by the Mura-Mura, in the midst of the sand-hills around Lake Perigunda (Lake Hope). These sand-hills could not have formed, if the country had then been well wooded, and they imply an arid climate as far back as the earliest, aboriginal legends carry us.

Other legends in the Lake Eyre district explain various geographical features, as due to incidents in the good old times, known as the Alcheringa.

Then the earth was inhabited by the Mura-Mura, half-mythical ancestors, to whom the lively imaginations of the aborigines have attributed supernatural powers.

Thus near Callana railway station, west of Hergott, there are two white hills, called Minakuka, which are said to be the eyes of Warrumandina, a Mura-Mura, who tore out his eyes in a passion, and threw them away. Some liver-coloured hills on the south-western corner of Lake Eyre, are said to be the remains of the liver of another Mura-Mura; he was being torn to pieces by a pack of dingoes, and in the agonies of death he plucked out his liver and threw it away.

These stories suggest that the Lake Eyre country was much as it is now when the aborigines entered it, and that they used them to explain the occurrence of the white and liver-coloured hills.

That some of the animal stories and the star legends of the Central Australian tribes are extraneous in origin is probable from their resemblance to those of some African races. They remind me more of the legends of the South African bushmen, than of those of any other race. Mr. Andrew Lang [1] has remarked, that the folklore stories of the Noongahburrah tribe in New South Wales "resemble the tales of the Zulus in character, though these [Zulu] represent a much higher grade of civilisation."

[1] Introduction to Mrs. K. Langloh Parker's *Australian Legendary Tales*, 1896, p. xvi.

The stories of the fabled Kadimakara of Lake Eyre are so indefinite, and show so many local variations, that their basis is not likely to be of local origin. It is most probable that the ancestors of the Central Australian aborigines once lived in a tropical forest-land. The adaptation of the stories to their new home is illustrative of that home-sickness, which led the old West Saxons to locate the death of Siegfried, and many of the incidents of the *Nibelungenlied*, near their new homes in Dartmoor; and which has induced the modern Australian, in spite of the confusion of geographical nomenclature, to give his newly raised southern towns such names, as Croydon, Hamilton, Maryborough, or Heidelberg, to keep fresh the cherished memories of his fatherland.

CHAPTER XV

THE GEOGRAPHICAL PLAN OF SOUTH AUSTRALIA

Spacious as fancy's boundless territory.
WATSON.

SOUTH AUSTRALIA, in spite of its enormous extent, has a simple geographical plan.

The backbone of the state consists of a long band of highlands, which runs from the promontory of Cape Jervis, northward past Adelaide and Port Augusta, and through the country east of Lake Torrens, till it sinks beneath the central plains of Desert Sandstone, between Lake Eyre and Lake Gregory. This band of highlands is composed of rocks of great antiquity; it was once a mountain-chain. But the original peaks have long since been worn away, and its ridges levelled, till the mountain-base remains as a rugged belt of country, which may be called the Highlands of South Australia. These South Australian Highlands separate two valleys—the Murray basin to the east, and the Great Valley of South Australia, including Spencer's Gulf and Lake Torrens, to the west. On the western side of the Great Valley is a broad, old plateau, which includes the basin of Lake Gairdner, the Gawler Range, and the barren

plains, that run inland from the Great Australian Bight.

The southern part of South Australia consists, then, of four main geographical elements—the Great Valley of South Australia, the South Australian Highlands, the Murray basin, and the Western Plateau. Their relations can be diagrammatically represented in the map opposite p. 236.

The first striking feature in South Australia is this division of the state into four bands, extending north and south. They are crossed by a less conspicuous series of transverse lines, which trend east and west, and were due to an older series of geographical incidents. There are three of these transverse geographical lines. The first is now represented only by a fragment, Kangaroo Island, wherein the rocks, that run north and south on the mainland, trend from east to west. The second of these lines connects the granitic rocks of the Gawler Range on the west, and the hills north of Olary,[1] near the eastern end of the railway to Broken Hill.

This Gawler-Olary line of elevation crosses the Great Valley of South Australia near Port Augusta, and breaks it into two divisions—Spencer's Gulf to the south, and Lake Torrens to the north. The third of the eastern and western lines occurs at the northern end of the Torrens basin, which is thus

[1] The four chief hills of this latter group are Binberrie Hill, Triangle Hill, Macdonald's Hill, and Pinery Hill.

separated from Lake Eyre. It crosses the old rocks of the Willouran Range south-west of Hergott; it passes through Farina and to the south of the head-streams of the Frome River, and goes along the northern end of the main Highlands of South Australia, where the hill-lines run east and west, instead of having their usual meridional trend. It ends to the east in the old Archean rocks of Mount Babbage, to the west of Lake Callabonna. This northern line may be called the Willouran-Babbage line.

From the end of the Willouran Range the old rocks of the South Australian Highlands continue north-westward, through the Denison and the Peak Ranges and Mount Dutton, till they disappear below the Desert Sandstone plateau of the district around Oodnadatta.

Still farther to the north, along the northern frontier of South Australia, and in the southern part of the Northern Territory, there occurs the best-developed series of mountains, running from east to west. They include the Musgrave Ranges in South Australia, and the many parallel ranges, which may be grouped together as the Macdonnell Chain, in the Northern Territory.

Owing to the north-western continuation of the old rocks through the Willouran and Denison Ranges, the country north of the Willouran-Babbage line is constructed on a very different plan from that of the area to the south. The Great Valley has disappeared; the South Austra-

lian Highlands end off abruptly against the Central Australian Plains; and the lowlands of the Murray basin have passed eastward, and are confined to New South Wales. Moreover, the great western plateau has been pushed to the west by the curve of the old rocks, that form the western and southern rim of Lake Eyre.

To understand the relations between southern South Australia, with its Great Valley, and northern South Australia, with the basin of Lake Eyre, it is necessary to consider more carefully the structure of the South Australian Highlands. Highlands are the worn-down remains of old mountain countries. The South Australian Highlands are the remains of what was once the chief mountain-chain of South Australia. A mountain-chain consists of a number of smaller mountain-lines known as "ranges," which, for the sake of greater precision, are sometimes called by the French name *chainons.* The South Australian Highlands consist of the bases of many such old mountain-ranges, of which the best-known series runs along the western border. The principal members of the series are: the Mount Lofty Range, near Adelaide; the Gregory Range, near Port Wakefield; the Flinders Range, near Port Augusta; the Ragless Range, near Hawker; the Yapala Range and the Elder Range, east of Lake Torrens.

Some mountain-chains, each composed of several ranges, branch off from the South Australian Highlands, both to the east and west. One of

them, going to the south-west, forms the backbone of the Yorke Peninsula; another runs north-west from the northern part of the highlands, near Beltana, and forms the Willouran Range and Mount North-west, near Hergott. This line is continued by a series of detached fragments, including White Hill, Mount Margaret and the Denison, Peak, and Kingston Ranges, into the region of the high plateau of Central Australia. Two important chains go off from the South Australian Highlands to the east. The first chain branches off at Petersburg, and forms the band of highlands, traversed by the railway to Broken Hill. At its eastern end, in New South Wales, it bends northward, and forms the Barrier or Stanley Range, and is continued, with Mount Arrowsmith as a detached outlier, by the Grey Range as far as Mount Shillinglaw. A second eastern chain runs north-eastward from the Elder Range; it crosses the main highlands, and includes Point Bonney, Mount Frome, and the Freeling Heights, beyond which it plunges below the central plain, to the west of Lake Blanche. Between the Freeling Range and the Barrier Range is the basin of Lake Frome, a vast depression, closed to the south by the Olary Hills, but open widely to the north.

The distribution of the mountain-lines, which determine the geographical features of South Australia, is the direct expression of the geological structure of the country.

The South Australian Highlands are composed of rocks of great antiquity, which in part belong to the periods known geologically as the Archean and the Palæozoic. The Gawler Mountains and the Olary Hills are formed of granitic rocks, which have probably been forced, while in a molten condition, into the overlying beds. At one time these granitic rocks probably formed part of a great mountain-chain that ran, east and west, across the whole width of southern Australia. At that time the Gawler-Olary line was part of the main watershed, from which rivers flowed southward into the Southern Ocean, and northward into a sea, which once extended from the Gulf of Carpentaria to the northern margin of the South Australian Highlands.

The mountain-lines that run eastward and westward are now less conspicuous in South Australia than the meridional lines which intersect them; but the former are the more primitive and ancient features. From the Gawler-Olary line the country sloped gradually northward into the basin, in which were deposited, first the marine clays that underlie the whole of the Lake Eyre basin, and then the great sheet of Desert Sandstone.

The disturbances which broke across the Gawler-Olary line, and formed the Great Valley of South Australia, belong to a period later than either the marine clays or Desert Sandstone of the central plains; and these northern and southern move-

ments are at present more conspicuous in their effects on the surface of South Australia. They cut right across the former divide, and, to the north of it, they bend westward, and apparently die out against the central plateau of Australia. Owing to their unequal development on the two sides of the divide, there is no apparent symmetry in the northern and southern divisions of South Australia. The great basin of Lake Eyre is confined between the mountain-lines of the Peak to the west and the Freeling Heights and Grey Range to the east. These two mountain-lines meet in the main Highlands of South Australia, and thus there is nothing in southern South Australia, which directly corresponds with the Lake Eyre basin.

Lake Eyre and Lake Torrens do not correspond geographically; for the line that forms the eastern rim of Lake Torrens is continued to the west of the Peak—far to the west of Lake Eyre. The two lakes do not agree either in age or structure; the Lake Eyre basin is much older than that of Lake Torrens, which occurs in a rift-valley made by the earth-movements, which have formed the Great Valley of South Australia. The faults which bound the rift-valley are of recent date, and are probably still in progress. The aspect of the cliffs of the Elder Range and of the Blinman Heights, east of Parachilna, at once suggested their recent formation.

On my return to Melbourne, Mr. Baracchi

kindly showed me the book of earthquake records kept at the Melbourne Observatory; and this list shows that the country around Beltana is repeatedly shaken by small earthquake-shocks, which, from their nature and distribution, are doubtless caused by slight earth-movements along the fractures that formed Lake Torrens.

Farther north, there are fewer earthquake records; but indirect evidence, that earth-movements are still taking place, is afforded by the well-known "desert sound," when the stillness of the night is often broken by a deep booming, which appears to rise from below the surface of the ground. This desert sound has been recorded by many observers, from Sturt to Winnecke. It appears to be most frequently observed along the line of the Peak Range, and is probably due to earth-movements along the northern continuation of the Lake Torrens faults.

Further evidence of this line of fracture is given by the series of mound-springs, which occur from Hergott Springs north-westward, along the junction between the rocks on the floor of the Lake Eyre basin, and the old rocks that form its western rim. These springs are due to the upraising of water, from great depths beneath the surface, along the fracture line.

In spite of the present geographical independence of the Lake Eyre and Lake Torrens basins, it is possible that they were once connected. A river may have flowed over the low gap (altitude

175 feet above sea-level), which occurs between the south-western corner of Lake Eyre and the north-western arm of Lake Torrens. But there is no evidence that Lake Eyre ever had an outlet, in that direction. So far as can be judged from the imperfect evidence now available, it is probable that the original outlet of the Lake Eyre basin, and of the Diamantina and the Barcoo was south-eastward into the Murray. The drainage of Central Australia was collected into Lake Eyre owing to a subsidence, by which the lowest part of the basin dropped below sea-level. It is quite possible that this subsidence happened at the time when the Great Valley of South Australia was formed. But even if that be the case, the original Lake Eyre basin was of very much greater age than that of Lake Torrens.

The geographical plan of South Australia may therefore be summarised as follows:

The country was originally traversed by a series of three mountain-lines, which ran east and west. Traces of these old eastern and western mountains can be seen in Kangaroo Island; in the granitic rocks of the Gawler Range on the west and of the Olary Range on the east; and in the foot-hills which trend east and west across the northern border of the main Highlands of South Australia.

The main divide at one period was probably the Gawler-Olary line. North of this line there are five chief land-forms: (1) the Western Plateau,

which is continuous with that of Western Australia; (2) the mountain-ranges extending from the hills south of Hergott to the Denison and Peak Ranges; (3) the great basin of Lake Eyre, once occupied by a sea, from which one estuary ran as far south as the northern end of Lake Torrens; (4) the Desert Sandstone plateau which separated the lakes of the Gregory and Blanchewater group from Lake Eyre, until this divide was broken through by the Cooper and the Diamantina; (5) the eastern plains of the Cooper and the lake-chain from Lake Gregory to Lake Callabonna.

On the south of the old main divide the land-forms are: (1) the Western Plateau; (2) the Great Valley of South Australia, including Lake Torrens and Spencer's Gulf; (3) the Highlands of South Australia, from Mount Lofty to Mount Hopeless; (4) the western part of the Murray basin.

CHAPTER XVI

THE DISCOVERY AND EXPLORATION OF LAKE EYRE

> There's a legion that never was 'listed,
> That carries no colours or crest,
> But split in a thousand detachments
> Is breaking the road for the rest.
>
> KIPLING.

THE story of the exploration of South Australia has been often told; but it has never been possible to do full justice to the pioneer work, done by unknown swagsmen and forgotten prospectors—the true heroes of Australian story. It is easy to follow the tracks of those who travelled for geographical research, for their achievements have been duly described by the press and in geographical literature. But the journeys of the pastoralists seeking for cattle-runs and of the prospectors searching for gold have not been recorded, and most of them have been lost beyond recall. There are many summaries of the exploration of South Australia, but none of them correctly state who was the actual discoverer of Lake Eyre. The man who named it is unknown; and it was only recently, after many men had joined in the search, that Mr. Hugh Wright, of

the Sydney Public Library, found that the name "Lake Eyre" was given in an anonymous article in *The South Australian Register* of January 27th, 1860.

The first impulse that led man to travel into the interior of South Australia was the hope of finding a better land behind the coast-zone. The exploration of the country was begun in 1802, when Flinders reached Port Augusta; and while he examined the head of the gulf by boat, his companion, the illustrious botanist Robert Brown, ascended the Flinders Range, and from the summit of Mount Brown saw inland as far as Mount Arden. The next step was in 1832, when Captain Collet Barker landed near Adelaide, and climbed Mount Lofty, a hummock near the western edge of the high plateau that bounds the Adelaide plains; he continued eastward across the hills to the mouth of the Murray, and swam across it to explore the other side, where he was speared by the aborigines. Adelaide itself was founded in 1836, and the hills behind it were soon traversed by its citizens. The Mount Lofty Range was explored by Morphett and three companions in 1837. The "Overlanders"—Hawdon, Bonney, and Eyre—who drove cattle from Victoria, discovered in their journeys the value of the hilly country between Adelaide and the Murray.

These journeys led to some disappointment regarding the coast-lands near Adelaide and the country behind it. The climate was hot, the

soil was dry and arid, and the rainfall irregular. Men, therefore, turned their attention northward, in the hope of finding, somewhere in the interior, a higher, cooler country, with a more abundant and more usefully distributed rainfall. The route inland from Port Augusta, at the head of Spencer's Gulf, promised to be the most convenient. Accordingly, on May 1st, 1839, thirty months after the foundation of Adelaide, E. J. Eyre started northward on his first expedition. He hoped that the broad valley, which Flinders and Brown had seen continuing Spencer's Gulf to the north, would lead to fertile highlands in the interior. Eyre reached Mount Arden, the farthest point seen by Flinders' expedition, and, still pressing northward, on the 18th of May he reached a hill, subsequently named Mount Eyre by Governor Gawler. In a view from the summit, he discovered the basin of a dry lake, to which, on his next expedition, he gave the name of Lake Torrens.

"To the north-west," wrote Eyre, "and extending to the north as far as the eye could reach, was to be seen a very broad, glittering stripe of what seemed to be water, but which I was inclined to think was not water, but only the dry and glazed bed of where water had lodged—and of very great extent. Nowhere could we see the least sign of grass or water; the hills before me were high, barren, and rocky, and there were no gum-trees or other indications of water emanating from them to be seen anywhere—the whole was barren and arid-looking in the extreme, and as I gazed at the

dismal scene before me I felt assured I had approached the vast and dreary desert of the interior, or, it might be, was verging on the confines of some inland water, whose sterile and desolate shores seem to forbid the traveller's approach."[1]

In August of the same year, Eyre started on his second expedition. He crossed Spencer's Gulf by boat to Port Lincoln, and marched north-westward to Streaky Bay on the Great Australian Bight; thence he returned overland, eastward to the head of Spencer's Gulf, discovering the Gawler Range on his way. He again reconnoitred the valley to the northward, riding ninety miles along its eastern border; and he saw more of the great salt lake, which he then named Lake Torrens.

The result of these two expeditions was to convince Eyre, that the most practicable route to the interior lay along the hills east of his Lake Torrens. And on June 18th, 1840, he started on his third and most famous expedition. Its object was to follow the Flinders Range to the north, in the hope that it would lead to high, mountainous country, across which it would be possible to reach the centre of the continent, and even cross it to the northern coast.

Sturt, on the other hand, did not believe that these mountains were continuous inland. He advanced the interesting theory, that Australia had once been an archipelago; its mountainous areas

[1] E. J. Eyre, "Expeditions of Discovery in South Australia," *Jour. R. Geogr. Soc.*, vol. xiii., 1843, p. 165.

represent the old islands, and the intervening tracts of salt swamp and salt lakes replace the old sea-bed. He thought that the Flinders Range, and the hilly country to the east of it, was one of the islands; and he expected that to the north of it, separated by a belt of salt swamps, there were other similar highlands, with a better rainfall and a richer soil than the southern part of South Australia.

To solve this problem, Eyre started from Port Augusta and founded a depot at Mount Arden. He continued to the north, past Mount Eyre, his former turning-point, and along the Flinders Range to Beltana, which he named Mount Deception. He was driven to the hills by lack of water on the plains, and he reached the peaks that he named Mount North-west and Termination Hill. Eyre thence sent back the rest of his men, and journeyed on for ten days, accompanied only by a black boy. On August 14th, 1840, he was stopped on the shore of a lake, which he regarded as the northern continuation of Lake Torrens. But "Eyre's Look-out," the point then reached, is a cape on the southern coast of Lake Eyre; so that Eyre was the first white man to reach the shores of the lake subsequently named after him. It was impossible to cross the lake; Eyre returned, and started northward again by a route farther to the east. He passed Mount Serle, and reached a mountain which he called Mount Hopeless, because the view from it showed a

long lake-plain, which again stopped his progress to the north or to the north-east. He thought this lake was an eastern arm of Lake Torrens, which he considered to be shaped like a horse-shoe, and to surround the Highlands of South Australia on all sides except the south. He concluded that this lake barred all access to the interior along the highlands from Port Augusta.

"Lake Torrens now faced us to the east," wrote Eyre, "whilst on every side we were hemmed in by a barrier which we could never hope to pass.... The lake was now visible to the north and to the east; and I had at last ascertained beyond all doubt that its basin, commencing near the head of Spencer's Gulf and following the course of Flinders Range (bending round its northern extreme to the southward), constituted those hills the termination of the island of South Australia, for such I imagine it once to have been. This closed all my dreams as to the expedition, and put an end to an undertaking from which so much was anticipated."

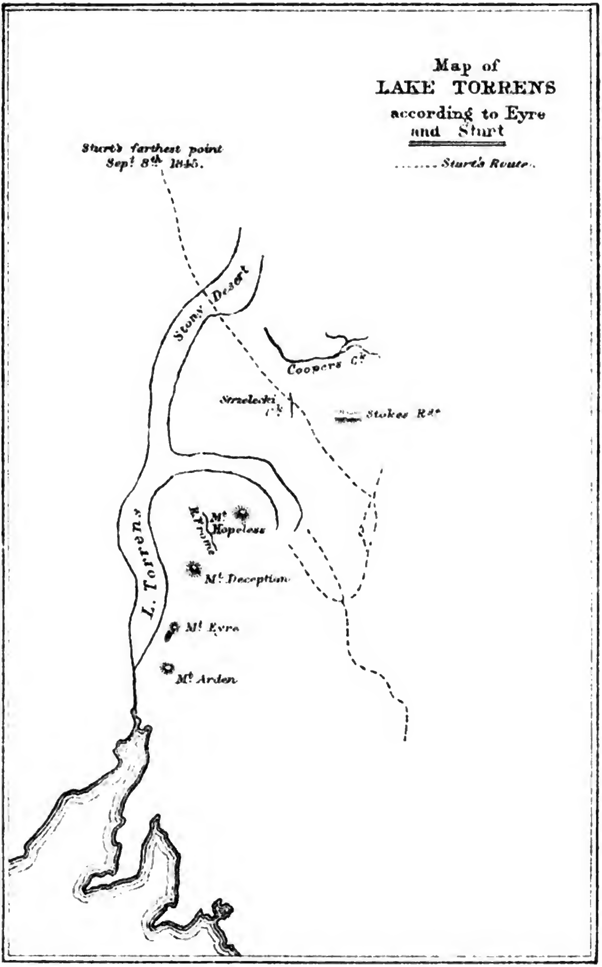
So Eyre returned to Port Augusta, intending to go northward again on the western side of Lake Torrens. But he changed his plans, and went westward on his famous journey round the Great Australian Bight—the most dramatic story in Australian annals.

Eyre's work appeared to show, that there was no road to the interior along the South Australian Highlands; so the next efforts at northern exploration were made either farther to the east from the Murray, or to the west, on the other side

of Lake Torrens. Sturt, in 1844, started northward on the eastern route from the Darling, keeping well to the east of the supposed eastern arm of Lake Torrens. He crossed Cooper's Creek, the upper part of which Mitchell had called the Victoria. He also reached the Diamantina, which he named Eyre's Creek; but his work threw no special light on Lake Eyre itself. He suffered terrible privations on the deserts to the east of Lake Eyre; and his progress to the north was stopped by the gibber plains, to which he gave the appropriate name of the Stony Desert. He concluded that both types of desert were parts of an old sea-floor, for he had been educated at the time, when it was the habit to regard water as the only geological agent worth consideration.

While Sturt was working to the east of Eyre's horse-shoe lake, J. A. Horrocks, in 1846, had started northward in the hope of reaching the interior by a route to the west of Lake Torrens. The expedition was remarkable because it employed the first camel used in Australian travel; but it was brought to an abrupt conclusion, as Horrocks was killed by the accidental discharge of his gun while mounting his camel.

The search for an easy road to the interior was then for a time suspended, and it was not until ten years later that further progress was achieved. The work began again along the South Australian Highlands; for colonisation had by this time extended, and the base of operations was much



Map of
LAKE TORRENS
according to Eyre
and Sturt
Sturt's farthest point
Sep. 8th 1845.
Sturt's Route.
Stony Desert
Coopers Ck.
Strzelecki Ck.
Stokes Rge.
L. Torrens
Mt. Hopeless
R. Frome
Mt. Deception
Mt. Eyre
Mt. Arden

farther to the north. In 1857 Goyder, then the Assistant Surveyor-General of South Australia, journeyed northward, and descended from the highlands to the great interior plains. He found the country much better than he had expected. He reached what he supposed to be the eastern arm of Eyre's horse-shoe lake, and to his delight he found the water was fresh, and its extent appeared enormous. He reported:

"Next day we continued our course to the north-east, down the bed of the creek, for about fourteen miles, passing over vegetation of the most luxuriant kind, which covers the valley for a width of from three to four miles; the timber in the creeks changing from lofty gums to a bastard peppermint, which was rapidly assuming a more stunted appearance, and the creeks bending away to the eastward. We then left the Macdonnell, and made for the nearest point of what was rapidly assuming the appearance of an immense lake; and after travelling about six and a half miles to the north-east, our doubts were set at rest—we were in latitude 29° 13′, and stood upon the margin of Lake Torrens, the waters of which were unmistakably fresh.

"From the spot where my observations were taken, the lake stretched from fifteen to twenty miles to the north-west, forming a water-horizon extending from north-west-by-west to north-west; the south portion terminated by high land running south towards Weathered Hill, at once explaining the cause of the various creeks bending so much to the eastward. An extensive bay is formed inside this promontory, extending southward to west-north-west, when the land again runs out to a point, approaching and passing us by a gentle curve

to the east, and inclining gradually to the south-east, and ultimately disappearing in the distance. The north portion of the horizon is terminated by a bluff headland, round which the water appears to extend to the north. This land passes thence to the east, and forms the north boundary of the visible portion of the lake; and, from a higher elevation than that upon which we stood, appeared to extend round to the eastern wing. It is covered with vegetation, as also are several islands seen between the north and south shore, apparently about five miles distant from where we stood, their perpendicular cliffs being clearly discerned by aid of the telescope.

"From the first, I had anticipated finding large lakes of fresh water at the termination of the various creeks, or one large lake into which a number of them discharged their waters. But in such I should have discovered flood-lines indicating the rise and fall of the waters; and, even supposing them to have attained their maximum height, the vegetation on some portion of the surface inside the water's edge would have revealed this fact. But, in this case, there was an entire absence of such marks, the water's edge being clearly defined; and the bed changing its character so suddenly from an alluvial soil to blue loam, covered by an inch of fine silt, renders it almost beyond the possibility of a doubt, that the surface of the water is subject only to the most trifling variation of level; and the absence of deltas at the embouchures of the creeks, tends to show that there is no reacting force, but that the waters, in times of flood, flow uninterruptedly elsewhere; and, I am inclined to believe, in a generally north-west direction.

"In using the words 'unmistakably fresh' with reference to this water, I meant to imply that not only did they appear fresh to the taste, but that

also there was no indication whatever of the presence of salt; and I only regretted the absence of the means which would have enabled me to test not only their extent and direction, but also their depths and action. . . .

"As Lake Torrens may probably become a depot for future observations in the northern districts (a properly constructed boat being placed upon its waters, enabling their nature and extent to be ascertained, and serving as a connecting-link between the two shores), I may be permitted to suggest what appears to me to be a very easy method of improving the line of road to that locality, and of rendering a tract of at least 30,000 square miles of country available for pastoral purposes."[1]

Goyder's report created great excitement in Adelaide. Freeling, the Surveyor-General, at once went up to superintend the exploration of the vast tract of country that could, it was thought, be opened up by the navigation of this inland fresh-water sea.[2] Freeling tells us that "the whole scope and object of the expedition was to penetrate north-westerly by water, and with this view it was fitted out and equipped." But Freeling was doomed to prompt disappointment. Since Goyder's visit the water had greatly diminished in amount, and it had accordingly turned brackish. No lake that would float a boat could be found. "Six inches was the deepest water that was met with,

[1] Goyder's Northern Exploration (Parl. Pap., South Australia, 1857, No. 72, pp. 2, 4).

[2] Freeling's Northern Exploration (Parl. Pap., South Australia, 1857, No. 193).

and that only in patches." Goyder's fresh-water lake had vanished, and his glowing accounts of the scenery on its shores were descriptions of mirage. Freeling reported[1]:

"I particularly regret to have to state that the report of Mr. Goyder, the Assistant Surveyor-General, upon the faith of which the expedition was planned, is, especially as regards the lake, very far from conveying an accurate idea of the country visited. The extensive bays described in that report, the bluff headlands, the several islands between the north and south shores, the vegetation covering them and their perpendicular cliffs, have all been the result of mirage, and do not, in point of fact, exist as represented."

The boat was abandoned, the party returned in disgust, and the highland road to the interior appeared to be again closed as surely as ever.

The next efforts to reach Central Australia were made to the west of Lake Torrens, and a powerful expedition was equipped under Babbage. This expedition is memorable from the importance of its discoveries, and the bitter quarrels which took place over it. The attacks on Babbage were so severe, that the reports on the expedition are among the most unpleasant reading in the annals of South Australian exploration. The whole of the blame of the alleged failure of this expedition was thrown upon Babbage. But the documents connected with the expedition show

[1] Freeling's Report on Lake Torrens and Country Adjacent (Parl. Pap., South Australia, 1857, No. 174, p. 1).

that this verdict was unfair. Apparently the South Australian Government did not understand the orders it gave to Babbage, and then it turned and rent him, because he did what he was ordered to do, and not what may have been generally expected of him. Babbage's orders were signed by F. S. Dutton, the Commissioner,[1] and told him to undertake—

"The thorough exploration, as far as practicable, of the country lying between the western shore of Lake Torrens and the eastern shore of Lake Gairdner, and thence northwards.

"The surveying and mapping of the country traversed.

"The surveying and mapping of the western shore of Lake Torrens, so as to remove the doubts at present existing as to the extent, direction, and outline of the lake.

"The surveying and mapping of the eastern and northern shore of Lake Gairdner in like manner.

"Accurately laying down on the map the latitude, and as correctly as possible the longitude, of all remarkable landmarks, ranges, water-courses, lakes, permanent fresh-water springs, and water-holes.

"Having performed this service as completely as circumstances will admit of, you will be at liberty, so far as may be consistent with the safety of the party, to push your explorations northerly —to round the northern shore of Lake Torrens easterly."

In accordance with these precise instructions, Babbage carefully explored the country between

[1] Babbage, Warburton, Geharty, and Parry, Northern Exploration (Parl. Pap., South Australia, 1858, No. 25, p. 4).

Lake Torrens and Lake Gairdner, and did most admirable geographical work. His methods were, in many respects, years ahead of his time. But the authorities in South Australia thought that Babbage was trying to make a flying trip across the continent. His slow progress was accordingly taken as proof of sheer incapacity. He was caricatured by the South Australian press, and was scolded by his Government, which instructed him to abandon his investigation of the area west of Lake Torrens, and to press on to the north. On receipt of these changed orders Babbage at once started work on fresh lines. He made a bold dash to the north, which was rewarded by the discovery, that what we now know as Lake Eyre was not part of Lake Torrens, but an independent lake. He called it Lake Gregory, after his second in command. But this discovery was too late to save Babbage. He had been already recalled to Adelaide, and P. E. Warburton, an officer in the South Australian police, had been sent out to take over the command of the expedition. Warburton overtook Babbage on the south-western corner of Lake Eyre, and sent him back to Adelaide. Babbage was anxious to return around the eastern side of Lake Torrens, and thus complete his journey round that lake; but Warburton roughly refused his consent, and Babbage had to go back the way he had come.

The unreasoning bitterness with which Babbage was assailed may be judged from the following

extracts from the report, written by Warburton to the Government[1] before he had overtaken Babbage:

"Although he may gain his object of finding a summer depot, yet that he is incurring great danger without the smallest real benefit—for when he has found a depot, he will be unable to get his main camp up to it. Of course I do not wish to augment any evil which may arise from proceedings which seem to me next to insane, by sending more men into the like danger."

"I am amazed when I consider Mr. B.'s ignorance, indifference, and rashness. I do not know his plans for the summer, yet I am able most positively to say that whatever they may be they are impracticable; and further, supposing his plans were not only practicable, but were already actually carried into effect, even then they would be useless. He cannot cart in summer, because the horses cannot work without water; he cannot cart in winter over the country westward or northward of here, because his carts would stick in the first bit of the rotten, stony country when it was wet."

"I beg to assure you that I will endeavour to do all that reason and prudence permit; but that I dare not throw good lives after bad ones by attempting to follow Mr. B."

Warburton had formed a very exaggerated view of the danger of travel in the Lake Eyre district. He censured what he called Babbage's "insane recklessness"; and as soon as Babbage had gone south, Warburton retreated to the nearest station

[1] F. S. Dutton and P. E. Warburton, Northern Exploration (Parl. Pap., South Australia, 1858, No. 127, pp. 2, 4).

to wait for the winter, and the expedition did nothing more.

The credit of the recognition of the separate existence of Lake Eyre belongs to Babbage, and his discovery was announced in the following passages from his report.[1] He reached Lake Eyre by following down Stuart's Creek till,

"fresh at its upper end, it came into a country where the soil evidently contained salt, and there the water was quite salt; but on going down the creek the character of the country somewhat improved, and we again found fresh water in it. As will have been seen from this account, I have traced Stuart's Creek, except at short intervals, from its rise in a large plain down to its final termination in Lake Gregory.

"On proceeding down the Stuart, we found, near the junction of a creek from the south-east, since named the Margaret, by Major Warburton, a pool of fresh water, and here I halted my party, whilst I went out myself to examine the country before us, having, however, previously traced down the Stuart into a large lake, which I named Lake Gregory. My first trip was made, in company with Jones, to the nearest hill of the Hermit Range, situated about twenty miles west of my position. At about sixteen miles we found a gum-creek with salt water, but no fresh water, although it might probably be met with by going higher up the creek. On ascending the hill, which stands up out of a plain, excepting on the western side, where high sand-ridges butted up against it, I could distinctly trace the shores of Lake Gregory trending northwards; but to the west and north-

[1] Babbage, Warburton, and Burtt, Northern Explorations (Parl. Pap., South Australia, 1858, No. 151, p. 9).

west, where I expected to see Lake Torrens, nothing but an extensive plain met my view—not a sign of a lake of any kind being visible. Immediately to the north north-west was also an extensive plain, of a somewhat higher level than the western plain, presenting low bluffs at its sides. To the south-east were the other isolated hills of the Hermit Range, and beyond them a distant blue hill of the Flinders Range, very probably Eyre's Mount North-west. To the south were several small isolated salt lakes, and extensive plains covered by low sand-ridges and scrub. According to the map of the 'Recent Explorations,' the Hermit Hill should be about thirty miles west of Eyre's tracks; but I found, subsequently, that a more recent map, supplied to Major Warburton, gave the distance as only fifteen miles. The height of the Hermit Hill is about three hundred and sixty-three feet above the ground at its base, and probably considerably more above the western plain. I feel, therefore, confident, from my view from this elevation, either that Lake Torrens does not extend so far northwards as this latitude, viz. 29° 37′, or that, if it does, it must be reduced to a mere inconsiderable channel, and might be readily crossed."

"My own belief, from what I then and subsequently saw, is that Lake Torrens turns up to Yarrawurta at its northern end, as at its southern end it does to the Beda Arm, and that between Yarrawurta and Lake Gregory there are only a few small isolated salt lakes similar to Lake Phibbs: sufficient, however, to impress Eyre—who, I believe only saw this country from a distance—with the idea that he saw the loom of a continuous lake."

The name which Babbage gave to the lake was inserted on many private maps, and was used

by some unofficial geographers. But, officially, Babbage was repudiated and his results ignored; for the Governor, Sir R. G. Macdonnell, refused to allow his discoveries to be inserted on the Government maps of South Australia. The name Lake Eyre was given by *The South Australian Register.* It suggested on January 27th, 1860, that

"both lakes had been discovered by Eyre, and had he not supposed them to be the same he would certainly have anticipated Mr. Babbage in giving a name to the northern one. He did virtually give it a name—that of Lake Torrens; and now that the progress of discovery has shown that in so doing he called two lakes by the same name, there is justice in his Excellency's suggestion that he should be permitted to decide to which of the lakes the original name should pertain. We think, also, that it would be a graceful and well-merited compliment to affix to the principal lake of the chain discovered by Eyre the name of the discoverer. Let it be ascertained by actual survey which body of water merits that designation, and then let it be officially determined to do honour to a man whose name is honourably associated with that of South Australia, by calling that water Lake Eyre."

Later in the same year that name was accepted by the South Australian Government, and it was first used officially in Goyder's Report of the Northern Triangulation.[1]

The western arm of Eyre's horse-shoe was thus divided into two distinct lake-basins; and the

[1] Parl. Pap., South Australia, September 17th, 1860, No. 177, p. 1.

eastern arm was soon to be dismembered even more effectually. This work had been begun by Babbage, who reported in 1857 that the eastern arm of Eyre's Lake Torrens was probably founded on a series of disconnected salt-pans; but he was unable to make a sufficiently close survey of the area to prove his suspicions. His opinion was established by the work of Parry, Stuckey, and Sir A. C. Gregory. Parry, on August 6th, 1858, reached a narrow, eastern arm from Lake Eyre, which is now known as the estuary of the Clayton. Though Parry did not definitely discover that this estuary was closed to the east, his map showed that it could not, at the most, be anything more than an insignificant strait. The complete separation of the eastern lakes was proved by Stuckey, who passed between Lakes Blanche and Gregory, at the point since known as Stuckey's Crossing. He found that they were separate, and showed that the supposed eastern arm of Lake Torrens was founded on a series of distinct lakes. A. C. Gregory, in his overland march from Brisbane to Adelaide in 1858, independently established the same fact.

Thus Eyre's great horse-shoe lake has been broken up into a chain of nine different members—Lake Torrens on the west, Lake Eyre on the north, and an eastern chain of lakes, including Lake Florence, Lake Palankarinna, Lake Kopperamanna, Lake Gregory, Lake Blanche, Lake Callabonna, and Lake Frome.

After the dismemberment of Lake Torrens, geographical interest was chiefly devoted to the search for good pastoral country around Lake Eyre, and to the endeavour to cross the continent from south to north. Mr. A. W. Howitt visited the country to the west of Lake Eyre in 1858, but found it unsuitable for pastoral occupation. The mountains, on the western rim of the Lake Eyre basin, were first explored in the expeditions of J. MacDowall Stuart. His second expedition in 1859 discovered Hergott Springs, and crossed the country between Lake Eyre and Lake Torrens. In his third expedition he penetrated farther to the north-west, and reached the centre of the continent. During this journey he discovered most of the principal peaks of the Denison and Kingston Ranges.

At about the same time, the continent east of Lake Eyre was being explored by Burke and Wills, and the numerous relief parties sent out in search of them. The Burke and Wills Expedition was the Australian, Franklin Expedition, as the explorers, after practically accomplishing their mission, perished, apparently owing to deplorable mismanagement. Burke and Wills themselves threw no important light on the Lake Eyre countries, for the notes they wrote were too meagre and unsatisfactory to be of any scientific use. But the expeditions sent to rescue them did magnificent work. Howitt, who found the relics of the expedition and rescued King, the only

survivor, added greatly to the knowledge of the country between the Strzelecki basin and the Lower Cooper, and he reached the Diamantina. Unfortunately, no detailed account of Howitt's journey has been published, except in so far as it bears on the rescue of King and the finding of the bodies of Burke and Wills. Meanwhile, the South Australian relief expedition under McKinlay had worked northward. From the South Australian Highlands it crossed the supposed Lake Torrens at Stuckey's Crossing, between Lakes Blanchewater and Gregory.

McKinlay's journey took place in a very favourable season, and the country which so appalled Stuart was described by McKinlay and his assistant Davis in glowing terms. They called it "a land of lakes and meadows," and mentioned the term "desert" only in ridicule. Their accounts of the fertility of the country led to some enterprising, South Australian cattle-farmers following in McKinlay's track, and taking up the country for cattle-runs. The Great Queensland Road was gradually opened up, and the settlement of the Lake Eyre basin was begun. The northern end of Lake Eyre and the lower parts of the Cooper and Diamantina were, however, still unknown. In 1866 Warburton was sent to complete the exploration of the lake, and he marched round its northern end. He was much impressed with the danger of the country, and had many adventures in quicksands and swamps. He tells us:

"I cannot faithfully picture this plain with the pen. To form a correct idea of it a man must ride over it, and let him carefully scan the heavens before he does so. To be caught there in a heavy shower (I say nothing of the river-flood) would, in all human calculation, be certain death. It is difficult and distressing to ride over it when quite dry, so cracked and rotten is it; but when wet it must be next to an impossibility for either man or horse to move upon it."

Warburton reached the Lower Diamantina, and he ascended it for some distance, but erroneously identified the river as the continuation of Cooper's Creek. In the early seventies the settlements in the Lake Eyre district were of sufficient importance to necessitate a land-survey and the introduction of official control. The cattle-station of Callana was established near Hergott, and that of Cowarie extended for eighty miles along the Diamantina. A careful survey of Lake Eyre and the surrounding country was therefore necessary, and it was undertaken in 1872-3 by J. W. Lewis. He prepared a map, showing the whole shore-line of the lake, and the lower parts of all the rivers that enter it. He corrected Warburton's mistake about the Diamantina, and mapped the course of that river and of the Cooper, from their mouths in Lake Eyre to the north-eastern plains. Lewis's sketch-map has served as the basis of the outline trigonometrical survey of the Lake Eyre country, by the South Australian Lands Department, and for the topography of Lake Eyre in Mr. H. Y. L. Browne's

excellent, geological map of South Australia. There is, however, still much to be done before we have an adequate account of the geography of the Lake Eyre country. The levels of the bed of Lake Eyre are still undetermined, and the distribution of water in it after floods is unknown. But Lewis's survey solved the last leading questions on the topography of Lake Eyre and its shores.

PART IV

THE DEAD HEART OF AUSTRALIA—THE CHANCES OF ITS REVIVAL

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CHAPTER XVII

THE FLOWING WELLS OF CENTRAL AUSTRALIA

I. THE SUBTERRANEAN WATERS OF CENTRAL AUSTRALIA[1]

" . . . For in the wilderness shall waters break out, and streams in the desert. And the parched ground shall become a pool, and the thirsty land springs of water: in the habitation of dragons, where each lay, shall be grass, with reeds and rushes. And an highway shall be there, and a way."—*Isaiah* xxxv. 6–8.

"When water is spilt, it cannot be gathered up."

"Carry water till you arrive at water; do not pour out what you have, in hopes of water on ahead."

"Remorse is a grandchild; in the end it will come, though it be late."
Suahili Proverbs.

"Everywhere extravagance in the use of water is condemned; though everywhere a selfish instinct induces it."—Alfred Deakin.

1. The Fate of the Central Australian Rainfall

In 1813, that dread enemy of Australia, drought, forced the settlers on the coastal plains near Sydney to find a way up those hills, which had hitherto hemmed them in upon the west. The pioneers crossed the Divide, and found, to their surprise, great rivers flowing away from the coast into the trackless western wilds. It was believed

[1] *Note on the Literature.*—Reference to most of the chief literature on these wells is given in the footnotes; but it may be useful to remark the chief sources of information. An excellent bibliography of the *Cretaceous Systems of Australia*, by Mr. W. S. Dun, is appended to the memoir by Pittman and David (*Journ. R. Soc. N. S. Wales*, vol. xxxvii., 1903, pp. cxl-cliii), and includes all the chief literature

that the survey by Flinders had proved that no considerable river had its outlet on the southern coast of Australia. So the fate of the rivers, that flowed into the interior, was the first geographical mystery in Australia. The explorations of Sturt and Mitchell solved this problem. The rivers did not end, as had been thought, in a vast inland sea; but they trickled out to the Southern Ocean, through the lagoons and sand-bars of the Coorong.

In modern times, the riddle of the rivers, that flow inland from the Eastern Highlands of Australia, has presented itself anew. For as soon as it was possible to compare the discharge of the Murray, with the amount of rain that falls upon its basin, it was clear that the river carried down to the sea only a small fraction of the water, received into its basin from the clouds.

on the wells. The best general account of the artesian wells and theories is in Pittman's *Mineral Resources of New South Wales*, Sydney, 1901, pp. 452-478. It deals more especially with those of New South Wales, but it includes an excellent statement of the general theory. The official data of the wells of Queensland are given in the *Annual Reports of the Hydraulic Engineer*, Mr. J. B. Henderson, published annually at Brisbane. The latest available is the twentieth, for 1904; but that is less detailed than the earlier ones, of which the seventeenth (for 1901) is apparently the latest, with full details and maps. The official data of the wells of New South Wales are given in the *Reports of the Conservator of Water* (Mr. J. W. Boultbee), of which the last detailed report was published in Sydney in 1901. Wells in South Australia are described in the *Reports of the Public Works Department*, issued annually at Adelaide; the latest available is for the year ending June 30th, 1904. Cox's book on *Artesian Wells* mainly concerns those of Australia. Amongst general memoirs the chief are those of Jack (1885, 1890, 1895, and 1897), David (1891, 1893, and 1903), Pittman (1896, 1902, and 1903), Boultbee (1898). The Mound Springs are described by Palmer (1884), Waterhouse (1863), H. Y. L. Browne (1889 and 1896). The detailed references to these papers can be obtained from Dun's bibliography.

Mr. H. C. Russell, the distinguished Government Astronomer of New South Wales, raised this question in a note entitled "The River Darling—the water which should pass through it."[1] He called attention to the insignificant quantity of water carried by the Darling River, compared with the abundant rainfall of the Darling basin, and asked, "What then becomes of the rain-water?" He calculated, in a later paper,[2] that the exact discharge of the Darling River was only 1·46 per cent. of the available rain-water. So the discovery of the course of the Murray gave no final explanation of the fate of the bulk of the water that the river would naturally be expected to discharge. As the rain that falls does not flow off over the surface, Russell concluded that it flowed into the Southern Ocean by subterranean channels. According to this conception, the essential geographical difference between Australia and other continents is, that their rivers flow on the surface and those of Australia flow underground.

The Australian rivers cannot always have been buried; for they must have been above ground in olden times, when Lake Eyre was full of fresh water and its shores were clad with vegetation. The revival of the "Dead Heart of Australia" appears to depend on the chance of restoring to the surface the waters, that now lie useless underground.

[1] *Journ. R. Soc. N. S. Wales*, vol. xiii., 1880, pp. 169-170.

[2] "The Source of the Underground Water in the Western Districts, *Journ. R. Soc. N. S. Wales for* 1889, vol. xxiii. p. 59.

2. Discovery of the Subterranean Waters

The existence of a large supply of water under the Western Plains of Queensland and New South Wales, and under the basin of Lake Eyre, was shown by the existence of the "Mound Springs" (*vide* pp. 88, 89), where the outcrop of the old rocks enables the buried waters to reach the surface. In 1880, the year after the publication of Russell's paper, Suetonius Officer, a Victorian squatter, sank two wells on his station at Kallara, in the west of New South Wales, in the hope of tapping this supply of underground water. His wells were successful, and he thus began the utilisation of that vast supply of water, which has done so much to promote the welfare of the arid plains of Central Australia.

Apparently by coincidence, artesian wells were opened in Victoria in the same year as Officer's enterprise. A well, sunk in Macalister Street, Sale, is said to have been the earliest artesian well in Australia. It was 237 feet deep, and gave a considerable flow; but the water soon corroded away the iron tubing,[1] and the well was choked.

[1] The composition of the water, according to an analysis by Cosmo Newbery, is:

Chloride of sodium	28·984	grains per gallon.
Chloride of magnesium	trace	
Carbonate of iron	3·017	,, ,, ,,
Carbonate of lime	0·727	,, ,, ,,
Carbonate of magnesia	6·443	,, ,, ,,
Clayey matter (in suspension)	0·545	,, ,, ,,
Organic matter and loss	0·356	,, ,, ,,
	40·072	

For information regarding the well at Sale I am indebted to Mr. T. E. Williamson, Inspector of Mines for the Gippsland District of Victoria. Other artesian wells in Victoria occur at Grantville (on Western Port) and at Lara, north of Geelong.

Though several artesian wells have since been sunk at Sale, none of them has been of permanent use.

Western Queensland has similar geographical conditions to New South Wales; it has an abundant rainfall on the eastern highlands, whence considerable rivers flow out on to the western plains, where they dwindle and perhaps disappear altogether. These Queensland rivers, also, discharge a very small proportion of the rain they should collect; so they too might have subterranean courses. In 1882 Dr. R. L. Jack, then Government Geologist of Queensland, came to the conclusion, that the geologic structure of Western Queensland gave promise of its yielding a supply of artesian water; but nothing was done to test his opinion until the terrible drought of 1885. Mr. J. B. Henderson, the Hydraulic Engineer to the Queensland Government, and Dr. Jack were then sent out to re-examine the western districts, and—if they thought the prospects favourable—to select a site for a deep bore. The whole downs offered good promise of success, and Blackall was selected for the first experiment, as that township was in the direst straits from want of water.

The Blackall bore was begun on December 3rd, 1885, and was completed in April, 1888. It was sunk to a depth of 1,663 feet, and at a depth of 1,645 feet, or 774 feet below sea-level, passed through a water-bearing bed. The water rose to the surface, and flowed out of the well at the rate of 291,000 gallons a day.

This brilliant success led to the boring of wells

in widely scattered localities. By June 30th, 1904, 973 wells had been sunk in Queensland, amounting to a total depth bored of 225·04 miles, at a cost of £1,485,264.[1] The deepest well is at Whitewood, Bimerah, and is 5,046 feet deep. Of these bores, 596 have formed flowing wells, giving a total flow of 62,635,722 cubic feet, or 390,846,909 gallons a day.

In New South Wales, by the end of June, 1903, 101 Government bores had been put down,[2] of which 13 were failures, 66 gave flowing wells, and 22 wells of which the water had to be raised by pumping. The total discharge is 54,000,000 gallons a day.[3]

In South Australia there are now 38 deep bores in the central artesian basin, which yield over six and a quarter million gallons of water a day, and have cost over £166,000. Of these wells, 2 are still unfinished, and 16 have been unsuccessful.

The area over which these wells are distributed is in Queensland 376,000 square miles, in New South Wales 83,000 square miles, and in South Australia 117,800 square miles. The artesian area is most extensive in Queensland, where it occupies 56 per cent. of the State.

3. The Use of the Well Waters

The presence of this vast supply of water in the arid regions of Australia has rendered possible a

[1] Twentieth Ann. Rep. Hydr. Eng., Brisbane, 1904, p. 3.

[2] New South Wales, Rep. Dep. Public Works for year ending June 30th, 1903, Sydney, 1904, p. 113.

[3] By June 30th, 1904, 291 bores, Government and private, had been made, resulting in 248 wells; the discharge from the Government wells for that year had fallen to 49,300,000 gallons a day.

great advance in their prosperity. As the water rises from the wells with great force, it has been proposed to use it for turning mills and driving motors. Thus, at Thargomindah, in South-western Queensland, the artesian water is used to drive an electric-light plant.[1] The well at Llanrheidol is used (by means of a Pelton wheel) for wool-drying. The water itself, however, is of far more value than its power.

Great hopes were entertained at first, that the water could be used for irrigation on an extensive scale. The total supply obtained from private and public wells in New South Wales is over 21,800,000 cubic feet a day, while the Queensland wells in the year 1903 yielded nearly 63,000,000 cubic feet a day. But the irrigation of ordinary crops in an arid country consumes a large quantity of water. Thus it is estimated in the Transvaal[2] that 1,000,000 cubic feet of water is required for the irrigation of eight acres. On this allowance the existing artesian wells of New South Wales would irrigate 100 square miles, while out of the 668,000 square miles in the State of Queensland, the wells would only irrigate 2,800 square miles. A common Australian estimate is that a daily supply of 1,000,000 gallons, or 160,000 cubic feet, will irrigate one square mile; so that 91,542 cubic feet of water are allowed per acre in Australia, against 125,000 in the

[1] Seventeenth Ann. Rep. Hydr. Eng., Brisbane, 1901, p. 69.

[2] W. L. Strange, "Design and Construction of Small Reservoirs for Irrigation and for Stock," Transvaal, Dept. Irrig. and Water Supply, Bull. No. i. p. 5.

Transvaal. But even accepting the lower estimate, the areas, which could be watered from the wells, are small in comparison to the vast areas in Eastern Australia, that lie idle for lack of water. Larger areas might be planted with dates, salt-bush, and other plants, which need much less water, and will flourish in salter soils than ordinary crops; but their products are of less value.

The limited extent to which irrigation by artesian waters is possible has been clearly pointed out by Henderson. He estimates that under the most favourable circumstances, and even if the water were lost neither by soakage nor evaporation, only one three-hundredth of the western districts could be irrigated. "I cannot subscribe," he says, "to the optimistic views of some people as to the possibilities of our artesian wells in the matter of irrigating grass lands for fodder."[1]

The use of these deep-well waters for irrigating is also restricted by their quality. The artesian waters are not always suitable for irrigation, being highly saline, and they are especially apt to be charged with carbonate of soda. If ground that has lain fallow for centuries is irrigated with these waters, it produces luxuriant crops for the first few seasons; but the evaporation of the water leaves a deposit of carbonate of soda, which is very injurious to the growth of plants. Hence by the time the soil is crusted with carbonate of soda, it is agriculturally ruined.

[1] Seventeenth Ann. Rep. Hydr. Eng., Brisbane, 1901, p. 16.

THE OUTLET OF AN ARTESIAN WELL.
From a Photograph lent by the Royal Colonial Institute.

Large tracts in the Delta of the Nile were rendered sterile by continuous irrigation with the comparatively pure water from the river, as it gradually choked the soil with noxious salts. This evil may be avoided by the use of appropriate manures, which would alter the poisonous carbonate of soda into two constituents, both of which would serve as plant-foods; or the salts could be washed out of the ground by a careful sub-drainage. But in either case, the agriculture must be skilful and perhaps expensive.

It will be objected that artesian waters have been largely used in America; but extensive irrigation there, as in Algeria and India, has been from shallower wells, yielding a purer water than the Australian, and occurring near large markets, so that the irrigated land is mostly used for intense culture. In areas such as Dakota, where the wells are from 1,000 to 1,500 feet deep, and the water sometimes contains 130 grains of solids per gallon, it has been recognised that irrigation is impossible. Thus it is calculated that the Jamestown well, discharging 540,000 gallons a day, would irrigate less than one square mile. "The expense of such water-supply," says Warren Upham, "is far beyond its prospective value for ordinary agriculture." [1]

Irrigation by artesian waters in Australia was a practical failure, where we saw it in the date-

[1] W. Upham, 'Artesian Wells in North and South Dakota," *Amer. Geol.*, 1890, p. 217.

plantation at Lake Harry. It has been most successful at Pera, ten miles from Bourke[1]; but even there, the partial failure of the well has given trouble, and the orchards are insignificant in size or yield, in comparison with the irrigation settlements beside the Murray at Mildura and Renmark.

The deep-well waters can be used to best effect in raising crops of lucerne and other fodders, which will support herds and flocks during periods when native food is scarce. Wide tracts of the central plains can be safely occupied by reliance on reserves of food, which can be raised by the irrigation of small areas.

The artesian waters have hitherto been of most service by keeping open stock-routes across deserts, that would otherwise be often impassable. Thus cattle raised on the fertile western downs of Queensland can now be driven across the deserts of the Lake Eyre country to the railway at Hergott; and a safe road has been opened across the arid plains in the north-western part of New South Wales, by a chain of deep bores, which yield unfailing supplies of water at intervals, along the way.

II. THE NATURE OF FLOWING WELLS

The increased use of the wells in agriculture depends on the extent to which the present supply can be increased, without exhaustion. And it is impossible to decide the amount of water available,

[1] See J. W. Boultbee, "Report on the Position and Progress of Artesian Boring in New South Wales," Public Works Dept., Sydney, 1901, p. 9.

unless we know whence it comes, and why it rushes so freely up the wells.

1. Flowing Wells

Wells that overflow at the surface of level country, without any obvious reason for the ascent of the water, have been known from remote antiquity. Their use dates back to prehistoric times in the Thebes[1] oasis in Egypt, in China, India, and Lombardy. The best-known type is called "the artesian," from Artesium, the Roman name of Artois, a province of Flanders in France, where one of them has yielded a continuous supply since the year 1126. There, as is explained by a diagram repeated in most elementary text-books of geology, some beds of porous limestone and sands are interbedded between two impermeable layers of clay. This series of rocks is bent into a trough, the two edges of which are the hills on either side of the low plain. This trough-like arrangement of the rock is known to geologists as "a synclinal"; and the fact that this synclinal includes a porous, water-bearing layer between two beds of impermeable rock, offers a simple explanation why the water rises in the wells. The rain that falls on the neighbouring hills sinks through the porous beds and accumulates underground. Fresh water is continually being added, until

[1] The ancient artesian wells at Thebes were discovered by Aime Bey, and were described by Lefèbre, "Lettre relative à un voyage dans le Senaar et aux puits artésiens des Oasis d'Égypte," Compt. Rend. Ac. Sci. Paris, vol. vii. (1838), pp. 595-598.

the whole permeable layer is sodden. By boring a hole in the middle of the trough, through the overlying bed of impermeable material, the water in the reservoir has a chance of escape. It is forced up the bore-hole by the downward pressure of the water at a higher level in the water-bearing bed. The ascent is due to the same force that causes water, when poured into one limb of a U-shaped tube to rise in the other limb. This explanation of the wells in Artois is quite satisfactory. The water can only be of superficial origin, because the water-bearing layer rests on an impermeable floor, which would prevent any water reaching it from below. The ascent of this water is probably due mainly, to simple hydrostatic pressure.

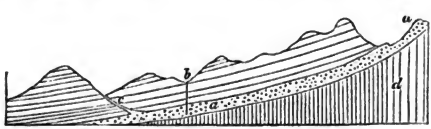
Similar cases have been found elsewhere. At Grenelle, near Paris, a bore, in 1835, after six years' work, was carried to the depth of 1,800 feet, where it reached a bed of sand, from which the water rushed up the bore-hole, rose sixty feet above the surface, and overflowed at the rate of 1,000,000 gallons a day. London and Paris both occur in valleys, where the rocks have been bent into trough-shaped folds. Sheets of clay lie on the floors of these valleys and cover water-bearing beds, which rest again on other sheets of clay; the water-bearing layer is exposed in the hills which form the sides of the valley. In these cases the ascent of the water may be adequately explained, as due to the pressure of the water at a higher level in

the porous beds. So these wells also are called "artesian."

In the artesian wells of Paris, and those at Merton and Mitcham, near London, the water rises until it overflows at the surface. In some cases, however, the water only rises partially up the tube of the well; and instead of overflowing, remains some distance below the surface, to which it has to be raised artificially. Thus in the deep London wells, the water only rises to within forty feet of the surface, and it has thence to be raised by pumping. But as the partial ascent of the water is due to the same force as that which causes the overflow in typical, artesian wells, they, also, are called "artesian" by some authors (*e.g.* by Prestwich); while they have been called "artesioid" by Clutterbuck; and in Australia they are generally known as "sub-artesian."

Flowing wells also occur in districts where the rocks are not bent into troughs, but are tilted into a long, regular slope.[1] This slope may be regarded as one limb of a fold of enormous width, of which

[1] These conditions may be illustrated by a figure from Lyell's *Principles of Geology* (7th edition, 1847, p. 235), in which *a a* is the porous



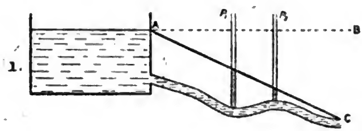
bed of sand, covered by impermeable rocks above and below *d*; *b*, an artificially flowing well, due to pressure in the upper part of bed *a*; and *c*, a natural artesian spring.

the other limb is unknown; so these wells also are regarded as "artesian." In yet other wells, the water overflows at the surface from water-bearing beds, which are certainly not part of any fold; for they may be traced as a straight, continuous layer, reaching to the shore and there sinking beneath the sea. These wells have been described as "artesian," on the view, that their water rises under pressure from the higher parts of the water-bearing layer. The water in this layer is, no doubt, flowing along it and discharging into the sea. Its escape is resisted by the sea-water; thus the water in the layer is under the combined pressure of the higher water behind it, and the resistance of the sea-water in front.

2. "Piezometers" and "Hydraulic Gradients"

The nature of flowing wells and the terms used in describing them may be illustrated by a simple experiment. Take an inclined tube, connected with a tank at the upper end, and closed at the lower end. Fill the tank with water. Then open the lower end of the tube, and it will be seen that the tube will be emptied more quickly if this end be held in the air, than if it discharges into a vessel below water. If a small hole be made on the upper side of the tube, water will escape from it in a jet. If a vertical tube be fastened over the hole, the water will rise in this tube. The height to which it rises is a measure of the pressure which it is under. Such a vertical tube is known

as "a piezometer"; and we can measure the pressure on the water at different points along a water-channel, by placing a series of piezometers along it. If we have a row of piezometers rising from a closed pipe, which runs sloping downward from a reservoir, the water will stand in all the piezometers at the same level as in the reservoir. If the



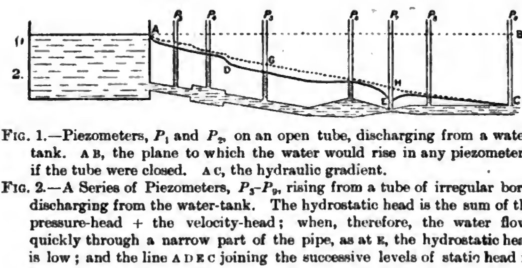


FIG. 1.—Piezometers, P_1 and P_2, on an open tube, discharging from a water-tank. A B, the plane to which the water would rise in any piezometers, if the tube were closed. A C, the hydraulic gradient.

FIG. 2.—A Series of Piezometers, P_3–P_9, rising from a tube of irregular bore, discharging from the water-tank. The hydrostatic head is the sum of the pressure-head + the velocity-head; when, therefore, the water flows quickly through a narrow part of the pipe, as at E, the hydrostatic head is low; and the line A D E C joining the successive levels of static head in the piezometers is irregular.

tube be quite open below, the water will only rise a short height in the piezometers. With the tap turned partly on, a line joining the level of the water in the successive piezometers will form a curve, sloping downward from the reservoir. This curve is known as "the hydraulic gradient."

In a uniform tube the hydraulic gradient would

be a uniform slope, from the level of the water in the tank, to the outlet at the end of the tube. But the hydraulic gradient would be irregular, if the tube varied in diameter, or were partly choked with sand, or had a rusty, uneven, inner surface. And the slope of the hydraulic gradient might be extremely variable and irregular.

Typical artesian wells, such as those of Flanders, are simply giant piezometers, rising from a porous, water-bearing rock.

3. The Sources of Subterranean Waters—Meteoric and Plutonic

Subterranean water may be derived from one of two sources. Cool water, which occurs at comparatively slight depths, is no doubt, generally, rain-water, which has percolated through the soil, or sometimes from the beds of rivers. As this water comes originally from the sky it is called "meteoric" water. The second source of subterranean water is the interior of the earth. The rocks of the deeper layers of the earth's crust contain water. The quartz in granite owes its milky whiteness to abundant minute cavities, filled with water. The vast steam cloud, which hangs over all active volcanoes, is due to the escape of steam from the cooling lavas; and it has, no doubt, been brought in them from the interior of the earth. As this water is of deep-seated origin it has been called "plutonic." Professor Suess names it "juvenile," as it is

making its first appearance on the surface of the earth.

Plutonic waters are especially important in mining countries, because most of the chief ore-deposits are due to them. And as the deep, water-bearing basin of Central Australia is surrounded on all sides by rocks, containing rich mineral veins—from the Queensland gold-fields on the east, the Cobar copper-field and Broken Hill in the south, and the Cloncurry gold-field in the west, there is likely to be a considerable amount of plutonic water under Central Australia.

Its existence appears sometimes to have been altogether overlooked; and the argument, that evaporation would carry off the whole of the rainfall in this district, has been dismissed as obviously impossible, because of the existence of artesian water.[1]

Where these ascending waters are cut off from the surface by an overlying sheet of clay, they accumulate in any porous beds they can enter, and remain in them subject to high pressure. Any plutonic water rising from the old rocks of Central Australia would collect in the permeable beds of sandstone beneath the clays. Thence it would rush to the surface, if a bore-hole were made through the water-tight cap above, just as oil and natural gas escape from the wells of the Caspian and Pennsylvania.

[1] "The Submarine Leakage of Artesian Water," *Proc. R. Soc Queensland*, vol. xii., 1897, p. 63.

4. Three Kinds of Flowing Wells

It is therefore possible to explain the occurrence of the deep-water supply in Australia independently of the present rainfall; and it is also possible to account for the rise of water in the wells, without relying on a remote source of pressure. Flowing wells may be due to three main causes. There are true artesian wells in which the water rises, owing to the pressure of water, at a higher level, in the same bed.[1] Other flowing wells are due to the expansive force of included gases, which may cause the water to flow to the surface gently, or may hurl it forth in sudden explosions, as in geysers. The ascent of the water in such wells may be due to its being charged with compressed gas—such as air, carbonic acid, or sulphuretted hydrogen—which readily expands when the pressure is relieved: the ascent of the water may also be due to its high temperature, which causes any gas in it to expand, or some of the water, on release of pressure, to be converted into steam.

A third class of flowing wells are those in which the water is forced to the surface, by the pressure

[1] The artesian wells along the Westralian coast near Perth afford a good illustration of the reascent of meteoric water under hydrostatic pressure. These waters afford a striking contrast to those of the wells of Central Australia. The water rises from the Perth wells from depths up to 1,800 feet, but its temperature from that depth is 91° Fahr., in contrast to that of 139° Fahr. from the 1,638-feet well at Clifton in New South Wales. The solid constituents range up to 90 grains a gallon, and are mainly sodium chloride—the natural salt to be obtained by percolation through sandy deposits of marine origin.

of an overlying sheet of impermeable rock.[1] If we fill a tin-bottle with water, close the opening with the exception of a pin-hole, and then press in one side of the bottle, the water—being under pressure —will rush out through the hole, in a fine jet. Similarly water imprisoned in a porous bed, lying beneath a heavy mass of watertight rock, will escape through any opening made for it in consequence of the weight above it. The enormous pressure exerted by thick masses of rock is well known to miners. For example, the coal from deep seams in the Belgian mines cracks into small pieces, when it is brought to the surface, owing to its release from pressure. A drive or tunnel cut through a bed of shale in a deep mine tends to close, as the weight of the overlying rocks makes the shale flow as if it were plastic, like mud. It is easy, therefore, to understand that water will be forced up a bore-hole, by the pressure of the overlying rocks.

These three types of flowing wells may be compared to the escape of water in a fountain,

[1] Attention was first called to the importance of rock-pressure in reference to flowing wells by R. Hay, "Artesian Wells in Kansas and Causes of their Flow," *Amer. Geol.*, vol. v., pp. 296-301. He maintains, that while some of the Kansas wells flow by hydrostatic pressure, others, as that at Mound Valley, are due to gas-pressure, and others, such as those in the counties of Pottawotamie and Morton, must be due to rock-pressure. It is not improbable that rock-pressure contributes to the overflow of the Grenelle well, as the pressure recorded there of 1,160 lb. per square inch is too high for hydrostatic pressure alone. See, *e.g.*, F. R. Gipps, "The Source of Artesian Wells," *Journ. R. Geogr. Soc. Austral.* (New South Wales Branch), vol. vi., 1896, p. 4.

a siphon, and a squirt. An ordinary fountain—in which water rises in a spray or jet, owing to the pressure of water in a raised reservoir—and the flow of water through the pipes of a town are both artesian, as their action is due to the simple pressure of water at a higher level. The outrush of water from a siphon, when the tap is opened, illustrates the ascent of water under gas-pressure. The jet of water from a squirt, when the reservoir is squeezed, illustrates the ascent under rock-pressure.

5. The Use of the Term "Artesian"

The flowing wells of Australia were called "artesian" on the supposition that the water in them rises in consequence of the downward pressure of the water at a higher level in the same bed, just as it does in the basins of Artois and Paris. It would no doubt have been better—and may yet be found more convenient—to restrict the name "artesian" to wells like those of Artois, as a special class of flowing wells. The wells which flow owing to gas-pressure or rock-pressure have been named by Daubrée "pelozemes" or "pelocones,"[1] in contradistinction to true artesian wells, which he called "eaux jaillissantes."[2]

But the name "artesian" has in English practice been given a wide and indefinite extension; and it is probably too late to object to this change

[1] Daubrée, *Les Eaux Souterraines*, vol. i., 1887, p. 389.
[2] *Ibid.*, pp. 157, 158.

of meaning, in spite of the serious, economic mistakes it has occasioned.

Some authors define the word "artesian" in its old sense. Thus the definition given in Spon's *Dictionary of Engineering* (vol. i., 1874, p. 145) is, "'An artesian well' is a shaft sunk or bored through impermeable strata, until a water-bearing stratum is tapped, when the water is forced upwards by means of the hydrostatic pressure due to the superior level at which the rain-water was received." But any flowing well may be called "artesian," as by Rey: "On nomme artésiens des puits creusés par l'opération du sondage, et de l'orifice desquels l'eau vient jaillir au dessus de la surface du sol." So also the late Sir Joseph Prestwich:[1] "I consider all these wells as 'artesian.' The same principle of compression of the water, by an impermeable mass of strata, below the level it would naturally take is applicable to all, although the variable level of the surface of the ground, and local exhaustion of the strata, limit the overflow to a few localities only." Professors Chamberlin and Salisbury, of Chicago,[2] go even further, and say that "any notably deep well is called 'artesian.'" Accordingly, there is no harm done by calling the flowing wells of Central Australia "artesian," so long as it is not thereby taken for granted, that the principles

[1] J. Prestwich, *A Geological Inquiry respecting the Water-Bearing Strata of the Country around London*, 1851 and 1895, p. 54.

[2] T. C. Chamberlin and R. D. Salisbury, *Geology*, vol. i., 1904, p. 229.

applicable to the wells of Artois will also apply to them.

III. EAST-CENTRAL AUSTRALIA AS AN ARTESIAN BASIN

The geological structure of East-central Australia is that of an artesian basin on a colossal scale. A wide extent of highlands runs all across eastern Australia, from Cape York Peninsula on the north to eastern Victoria on the south. These highlands are composed of old rocks, which are so hard and compact that they are practically impermeable, and the rock-layers have been so contorted and uptilted that many of them are standing on edge.

This country being near the ocean has a considerable rainfall, and the conditions are not favourable for much of this rain percolating underground. All that is not lost by evaporation, or absorbed by the soil, runs off into the streams and rivers. Some of the rivers that flow down the western flanks of the highlands reach a bed of very porous sandstone, into which water can soak underground. These sandstones slope downward to the west, and disappear from view beneath wide sheets of clays and loams, that form the Western Plains of Queensland and New South Wales, and the Central Plains of South Australia.

These sandstones, moreover, rest on beds which are in the main impermeable; so that under Central Australia we have a series of porous beds, exposed

at the surface along their eastern edge, and confined between two impermeable sheets. The artesian wells have been bored through the overlying clays, and the water rushes up under great pressure, and outflows in large volume. Moreover, it is found that as we go further and further to the south-west, the water will not rise to the same height above sea-level. So there is a hydraulic gradient which slopes south-west, as there should be on the theory that the bores tap a subterannean stream, which is flowing south-westward, from the high intake area on the mountains of eastern Australia. Mr. J. W. Jones, of Adelaide, calculated the height to which the water should rise in some localities; and in wells put down there, the water rose to the expected level. These successful predictions appeared to give convincing proof of the truth of the artesian theory.

Such are the grounds which have led most Australian geologists to the belief, that the ascent of the water in the flowing wells of Central Australia is due to the pressure of water, standing at higher levels in the hills of eastern Queensland and New South Wales. This explanation regards the numerous artesian wells of Central Australia as piezometers, rising above a water-bearing layer; and accordingly the level to which the water will rise in the wells gradually decreases, as we go seawards from the intake area in the Queensland hills. For the Queensland hills represent the tank in

the experiment described on page 285; a line from the water-level in the hills to the surface of the sea will be the hydraulic gradient, above which the water cannot rise. The determination of this slope, however, is not a simple matter, as it is not a regular plane; for the piezometric gradient varies in height with the varying resistance to the flow of water in its channel. The height of the water in adjacent artesian wells is found to differ greatly. Such cases were explained as due to obstructions to the movement of the underground water. Where the buried channel is unobstructed, the current of water would be rapid; the water would therefore be at a lower pressure —and would rise to a less height—than where the passage is obstructed, and the water is under greater pressure. Accordingly it was suggested that in localities where the water rose less than was expected, the subterranean waters circulated with especial freedom, and the water-level was naturally lower than in regions of obstructed circulation, where the water would be subjected to greater pressure. The irregularities in the water-level are so numerous, that it appears impossible to obtain a mathematical expression from which to calculate the height to which the water will rise in any locality. A formula has been worked out by Mr. J. H. Mitchell, F.R.S., of Melbourne University; but the factors are so many and so uncertain, that the problem defies satisfactory mathematical treatment, and Mr. Mitchell tells

me that he attaches no special value to his formula. The factors that have to be taken into account include the coarseness of grain of the water-bearing layer, its thickness and width, its slope, its depth from the surface, and the rate of passage of the water through it. The water-bearing beds sometimes occur at a depth of 5,000 feet; and as all we know of the beds in Central Australia is learnt from the fragments brought up by the boring appliances, we can have no adequate knowledge of these factors except the depth of the strata. We may be able to determine the grain of the water-bearing rock at the actual point reached by the bore; but such rocks are generally very variable in grain, and their coarseness may vary greatly within the distance of a few yards. The thickness of the deposit will also vary, and its width cannot be estimated from the few widely-scattered bores, that have reached it. It is, therefore, not surprising that mathematical attempts to calculate the probable yield and water-level in these bores have been disappointing, and that these failures did not shake faith in the theory on which they were based.

1. The Remote Sources assigned to the Waters

The tendency has always been to assign the origin of the flowing wells to distant localities. The ancient Egyptians supposed that the water which flowed from the artesian wells of Thebes came from the hills of Darfur, 700 miles to the

south. The reinforcement of the water in the London wells from the Thames—which crosses the chalk from Purfleet to Erith—has been generally overlooked, in favour of the chalk-hills in Hertfordshire, twenty-five miles to the north.[1] The source of the water of the famous well at Grenelle, near Paris, has been attributed to the Jura Mountains. It is, therefore, only in accordance with precedent, that the source of the deep-well waters of Lake Eyre should be sought in the mountains of New Guinea, the Andes, and the Himalaya.

The possible origin of Australian, artesian water from the Himalaya or New Guinea was suggested, amongst others, by the Hon. J. T. Murray Prior, in a debate in the Queensland Legislative Council. "The great question must be," he said, "where does the artesian water come from? The nearest high mountains we have to Australia are in New Guinea; but still the water may actually come from as far as the Himalayas, under the sea."[2]

2. The Hypothetical Subterranean Rivers and Outlets to the Southern Ocean

The explanation that the water in the artesian wells of Lake Eyre rises in obedience to the pressure of the water in the Queensland Hills,

[1] The contribution of the tidal-waters of the Thames to the London wells has been clearly recognised, as a result of chemical study, by Sir Lyon Playfair, Homersham, Frankland, and Odling.

[2] Queensland Parl. Debates, Legis. Council, June 13th to November 13th, 1891, vol. lxiii. 1891, p. 227.

600 miles to the north-east, is most attractive in its simplicity; but faith in this theory has been sapped by the frequent changes in it, that have been found necessary with increasing knowledge. The estimates as to the river-flow of the Darling made by Russell were rough approximations, which have been disproved by later measurements.[1] The Murray River and the Darling both discharge about the same proportions of the water, that falls upon their basins; and, considering the climate and the nature of the country that they drain, the amount is not unduly low. It is true that the Thames basin between 1883 and 1891 received an annual rainfall of 27 inches, and the river discharged 33·5 per cent. of this amount. The Sudbury River, Massachusetts, discharged 49·5 per cent. of the rainfall between 1875 and 1890. But these rivers are not comparable to those of Australia. The rainfall of arid regions is sometimes entirely lost by evaporation.

The subterranean rivers of Central Australia were thought to carry their waters westward, from the eastern hills to the Southern Ocean, by two main channels. One buried river was believed to follow the course of the Darling Valley, flowing under the Riverina into western Victoria, and thus to pass into the Southern Ocean between the Murray and the Glenelg. Its mouth was thought to be

[1] The discharge of the Darling, according to the Conservator of Water for New South Wales (Ann. Rep. 1891), is six per cent. of the available rainfall.

marked by many springs of fresh water along this coast, both on the shore and under the sea.

This outlet was, however, proved to be impossible by the discovery that the artesian basin is closed to the south by a ridge of old rocks across the Darling Valley, as was pointed out by Murray and Cecchi, of the Victorian Water-supply Department. Mr. Stuart Murray, the Chief Engineer of Water-supply in Victoria, discussing the chances of finding artesian water under the Mallee districts in the north-western part of that State, concluded[1] "that the artesian water found in Queensland and the northern part of New South Wales does not come into Victoria at all, but is cut off by a deep ridge of Silurian rock." But, still convinced of the necessity of a southern outlet, he adds that it "finds its way to the sea at the head of Spencer's Gulf, and does not come to the Mallee." There is, however, even less chance of the water escaping into Spencer's Gulf than into the Lower Murray.

The supposed subterranean river that was thought to flow by a more westerly route under the site of Lake Eyre, and thence to the Southern Ocean in the Great Australian Bight, is also almost impossible. Along the Bight there are many

[1] Prog. Report on Mallee Water-supply, Parl. Pap., Victoria, 1900, Railways Standing Committee, Rep. No. 8, p. vii. See also J. P. Thomson, and A. C. Gregory. *Proc. R. Geogr. Soc. Austral.* (Queensland Branch), vol. xi. (1896) p. 70 and pp. 73, 74. Thomson holds that the leakage from the water-bearing layer is from inland springs, and that drainage from it to the sea is almost impossible. Thomson, *Queensland Geogr. Journ.*, vol. xvii. (1902), p. 21.

submarine springs of fresh water; and when the sea is still, there may be seen swirling, ascending columns of a material, that is said to look like oil; but no oil can be found upon the surface. The descriptions suggest the ascent of fresh water from powerful springs, working its way up through the heavier salt water. The springs no doubt exist, but they are probably derived from the rain, which falls on the adjacent coastlands; for it is now known that the Lake Eyre basin is bounded to the west and the south by old rocks, that dam back the water from escaping to the south.

The only available outlet for the subterranean waters of the artesian basin is northward, over a rock-barrier, into the Gulf of Carpentaria, or possibly eastward to the South Pacific near Brisbane. Artesian water occurs in the country to the south of the Gulf of Carpentaria; but it need not have come from any distant area, as the broad sheet of Blythesdale Braystones, south-east of Normanton, would be quite sufficient to account for it; and the section on page 306 shows that an outlet to the Gulf of Carpentaria is of no use to the deep basin beneath the Lake Eyre country, for its waters are far below the level of the outlet into that gulf. Hence, so far as concerns the flowing wells of the south-western part of the central artesian basin, the water would be stagnant, as its only flow would be the small outlet through the wells and the mound-springs. The upholders of the artesian theory insist that the water must

be flowing onward; for they regard the wells as piezometers on a subterranean stream.

IV. WHY THE WATER RISES IN THE AUSTRALIAN WELLS

1. The Resistance to the Flow of Water through Rocks due to Friction

The explanation of the flowing wells of Central Australia as due to water-pressure in the distant Queensland hills is met by many difficulties. One of the chief is, that it underrates the resistance to the flow of water through rocks due to friction. The analogy between the geological structure of eastern Australia and a U-tube fails, because Australia is not built up of tubes. The water has to percolate, not through open tubes, but through the pores of rocks; and as these rocks are under the pressure of sometimes as much as four or five thousand feet of overlying material, the pores will be minute.

The stagnation of water by its friction with loose sand may be illustrated by the well-known case of the Kilsby Tunnel, on the London and North-western Railway, near Rugby. The tunnel had to be cut through a quicksand saturated with water, and it was first expected that the whole of it would have to be pumped dry. But the resistance of the sand to the flow of water was so great, that it was only necessary to pump a dry pathway along the line of the tunnel, leaving the water banked up on either side. The friction

with the sand held back the water as securely as a dam.[1] This illustration is especially instructive, as it shows within how limited a range the hydrostatic pressure of water will be felt through a loose sand or a porous rock. The pressure can only be felt to any distance, through open fissures and channels; and no continuous network of such is at all probable between Lake Eyre and the Queensland hills.

The existence of large fissures would be prevented by the pressure of the overlying rock-masses. But even if there were open tubes running from Queensland to Lake Eyre, it is doubtful whether the water would rise with any force from the lower end, in consequence of the weight of material in the Queensland hills; for the friction between the water and the sides of the tube would far outbalance the pressure. If the water were circulating with infinite slowness the action might take place, as friction is reduced very rapidly with decrease of velocity; but water moving so slowly would not rush from the wells with such force as it does from many of them.

The flow of water through a pipe is checked by the resistance of the sides of the pipe to the movement of the water. According to Merriman,[2] "this velocity is found to decrease as the length

[1] An account of this operation was given in 1898 by Prof. Boyd Dawkins, in the James Forrest Lecture, to the Institution of Civil Engineers; *Engineering*, March 25th, 1898, p. 383. The draining of the deep leads in Victoria gives striking analogous instances.

[2] *Treatise on Hydraulics*, p. 162.

of the pipe increases, other things being equal, and becomes very small for great lengths, which shows that nearly all the head has been lost in overcoming the resistances." The loss of head by friction is proportional to the length of the pipe; it increases with the square of the velocity; it decreases with the diameter of the pipe; it increases with the roughness of the interior surface, and it is independent of the water pressure.[1]

In a pipe 10,000 feet long and 1 foot in diameter, in which the water is flowing 5·41 feet per second, the friction-factor will be ·021. The loss of head will then be 96 feet. Such a tube 100,000 feet, or less than twenty miles long, would not discharge water at that velocity, unless from a tank raised 960 feet high. In the case of the deep-seated waters of Central Australia, the velocity will be much lower than that assumed; but the diameter of the pipe would be only that of the interstices between the sand-grains, and the effective diameter would be very much less than in

[1] These five facts may be expressed in a general formula:

$$H = F \times \frac{L}{D} \times \frac{V^2}{2G}$$

where H is the loss of head; L, the length of the pipe in feet; D, its diameter; F, a friction factor which depends upon the roughness of the inner surface of the tube; V, the velocity; and G, the normal acceleration due to gravity.

A table of friction factors is given by Merriman (p. 168):

Diameter in feet.	Velocity in feet per second.				
	1	2	4	10	15
·05	·047	·041	·034	·029	·028
·5	·028	·026	·023	·020	·019
1	·025	·024	·022	·018	·017

the above illustration. Merriman gives a rule that for pipettes less than ·03 inches in diameter, the velocity of the water will be $a \times \frac{HD^2}{L}$. In this formula a is a factor which is nearly constant for a given temperature; it is twice as great at 113° F. as at 50° F.

In ordinary pipes, reducing the diameter increases the friction in a much greater ratio. According to Box,[1] reducing the diameter by a quarter increases the loss of head 1,000 times. Increasing the length also reduces the effective head. Thus a pipe an inch in diameter, discharging a gallon of water per minute, has a loss per yard of ·0041 feet of head. If the pipe be a mile long it would use up 7 feet of head, and 100 miles would use up 700 feet. From Lake Harry to the nearest point of the assumed intake is over 600 statute miles. A small pipe could only carry water from the Queensland hills to Lake Harry, if the water flowed with extreme slowness. The weight of water 600 miles away could not exert any heavy pressure on the other end, and force the water there to rush quickly from the pipe. In a pipe filled with sand, the friction between the water and the sand-grains would soon sop up the whole of its head.

A further illustration of the powerful effect of internal friction in pipes is given by the diminution of the flow when pipes are allowed to become

[1] Box, *Hydraulics*, p. 36.

rusty. For example,[1] a pipe at Torquay, fourteen miles long, and ranging from 10 in. to 8 in. diameter, only discharged 317 gallons per minute. The pipe was then scraped out, and the discharge was increased to 634 gallons. A mere layer of rust on the inside of this wide pipe caused a loss of 50 per cent. of the actual discharge. Folwell[2] quotes an instance of an old 4-in. pipe discharging, owing to increased friction, only one-eighth the amount that it should have done; and he describes a 48-in. pipe, which, owing to the roughness of the inside, decreased its discharge from 25 to 30 per cent.

In the case of the subterranean water in Central Australia, the water has to pass through fine-grained and rough material, such as sandstone. It practically flows through minute tubes, of which the inner surfaces are roughened. Accordingly, it is inevitable that the hydrostatic head of the water in the Queensland hills would be used up, long before the water reaches some of these flowing wells. If the water flowed to the surface very slowly and with little power, we might assume that the water below was moving with such extreme slowness, that the friction-factor had been reduced to a negligible quantity. The water, however, sometimes comes up with high velocity, and with pressures amounting to 200 pounds to the square inch. The friction, therefore, cannot

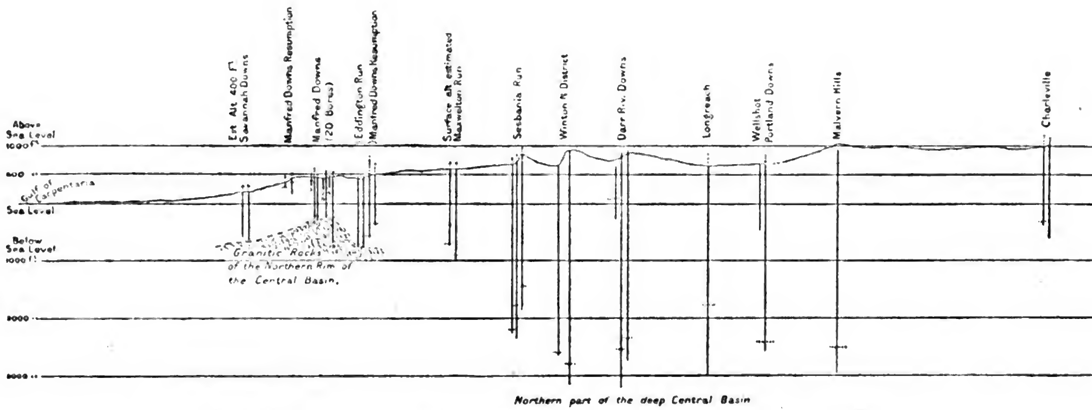
[1] Box, *Hydraulics*, p. 36.
[2] A. P. Folwell, *Water-supply Engineering*, 1900, pp. 216, 218.

be reduced below a factor, which would be sufficient to obliterate the whole of the hydrostatic head from any distant sources.

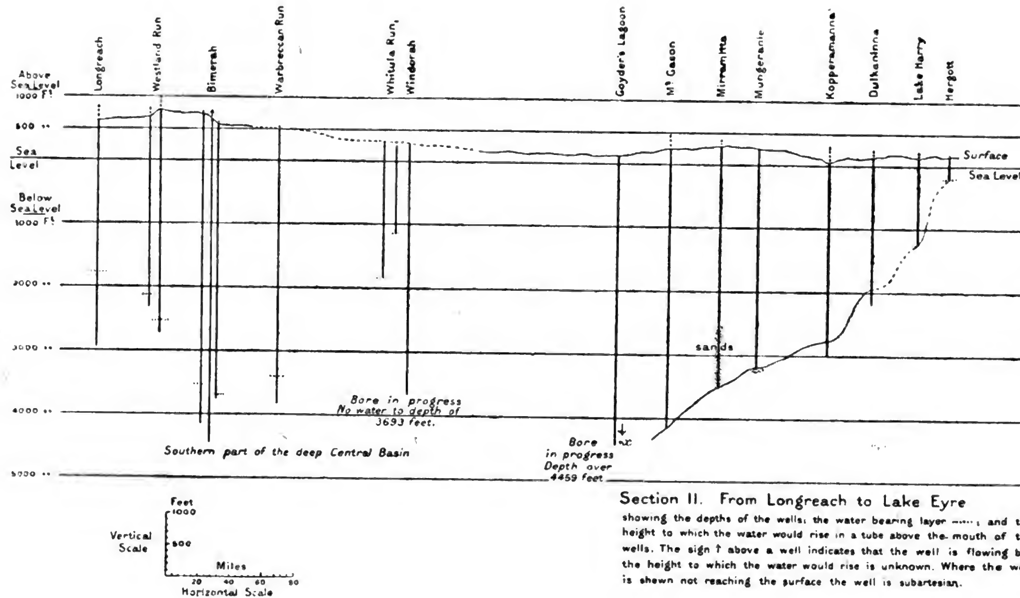
2. Irregularities in the Distribution of the Water and its Pressure

We have already seen that, in a complex artesian basin, the hydraulic gradient will not be a regular uniform slope from the intake to the level of discharge. But when we turn to the distribution of water-pressure in Australia, we find that it is far more irregular, than can be explained by the complexity of the water-bed. It is true that the level to which the water will rise from the wells is greatest at two localities in the Queensland hills, and from these high-pressure areas there is, speaking generally, a fall north-eastward to the Gulf of Carpentaria and south-westward to Lake Eyre. Mr. J. B. Henderson, of Brisbane, has constructed maps with isopotential lines, showing the levels to which the water will rise at various localities, and these look, at first, as if we were dealing with a simple, hydraulic gradient. Map No. II. gives the isopotential lines and the height of representative wells in the area; but the figures for the wells show that the levels are so irregular, that they defy any one general explanation. The local differences are so great that some varying, local causes must be acting. A section across the wells from the Gulf of Carpentaria to Longreach, and thence to Charleville,

20



Section 1. From the Gulf of Carpentaria to Charleville showing the depths of the wells, the water bearing layer ......, and the height to which the water would rise in a tube above the mouth of the wells. The sign ? above a well indicates that the well is flowing but the height to which the water would rise is unknown. Where the well is shown not reaching the surface the well is subartesian.



Section II. From Longreach to Lake Eyre

showing the depths of the wells; the water bearing layer ------; and the height to which the water would rise in a tube above the mouth of the wells. The sign ↑ above a well indicates that the well is flowing but the height to which the water would rise is unknown. Where the well is shewn not reaching the surface the well is subartesian.

is shown on page 306 ; and the figure on page 307, a branch from the first section, shows the relations of the south-western wells, from Longreach to Lake Eyre.

The longest series of the wells is that running from Lake Eyre north-eastward to Longreach, and thence north-westward to the Gulf of Carpentaria. The approximate height of the surface, the depth of the wells, and the height to which the water will rise at the wells are shown on the sections on pages 306 and 307. The general distribution of the wells is shown on Map No. II., upon which are inserted the isopotential lines, based in the main on those of Henderson for Queensland, and those of J. W. Jones of South Australia. The map shows that the pressure is highest in two areas: one to the north-east of Hughenden and the other north-east of Charleville. Thence the water-levels in the wells sink north-westward to the Gulf of Carpentaria, southward into New South Wales, and south-westward to the Lake Eyre country. This general plan, however, is interrupted by many local exceptions. The sections show the exact heights to which the water will rise in various wells. At the Darr River Downs the water-level varies in adjacent wells from 635 to 900 feet. The wells on the Manfred Downs vary from 350 to 618 feet, and on the Eddington Downs, where, according to Henderson's isopotentials, the pressure should carry the water above the height of 700 feet, it

only rises to 420 feet. The 700-feet isopotential line passes from Glenora south-westward and southward to Whitula Run; thence we should expect it to continue southward to join the 700-feet line that runs near the 29th parallel; but another 700-feet isopotential occurs north of Goyder's Lagoon. This line appears to indicate that there is an independent source of water-pressure in South Australia, in the area north of Lake Eyre and south of the Adam Mountains.

The high-pressure areas near Hughenden and at Charleville are not exactly where one might expect them to be on the view, that the water is taken in from the Blythesdale Braystones; because north of Hughenden those rocks are not shown as occurring on the surface, which is occupied by a wide sheet of basalts. Basalts also occur in the high-pressure area east of Charleville, where it is true they are associated with outcrops of the Blythesdale Braystones. The occurrence of the high-pressure conditions in areas of former volcanic activity is significant; for it is in such localities that we should expect unusually high, subterranean temperatures; and such temperatures would be quite sufficient to cause the high pressure in the water.

The sections show frequent local variations from the assumed hydraulic gradient. These are shown in the following table, which gives the height of the ground above sea level, and that to which

the water rises in the wells or would rise above them in a pipe, in the line of wells, from Manfred Downs to Whitula Run. Amongst other features, it will be remarked that wells at Eddington Run (No. 83) only rise to 420 feet, whereas in the adjacent well on Manfred Downs Resumption (No. 124) the water-level is as high as 818 feet. And north of the Eddington Run, instead of the water-level being lower, it rises at Manfred Downs as much as 200 feet higher. From Longreach or Charleville south-westward to Lake Eyre, there is a decline in the water-pressure to Whitula Run, and thence it rises again to Goyder's Lagoon and Mount Gason, whence it again falls slowly to Hergott.

		Height above sea-level. Ft.	Static head. Ft.
165.	Savannah Downs		
123.	Manfred Downs Resumption	355	412
122.	Manfred Downs	420	?350
		420	420
		438	442
		438	450
		438	515
		438	528
		410	562
		450	613
83.	Eddington Run	400	400
		415	420
124.	Manfred Downs Resumption	500	?700
		468	?818
128.	Maxwelton Run		
168.	Sesbania Run		
195.	Winton N. District	648	
		907	
77	Darr River Downs	755	635
		845	901
		802	880
xx.	Longreach	625	850

	Height above sea-level. Ft.	Static head. Ft.	
189. Wellshot Run	789	924	
	890	970	
	913	975	
121. Malvern Hills	?1020	?962	(58 ft. below surface)
xxix. Charleville	979	1161	
191. Westland Run	678	816	
	746	927	
25. Bimerah	710	780	
	589	?599	
186. Warbreccan Run		15 ft. above surface.	
192. Whitula Run		70 ,, below ,,	

The artesian wells in New South Wales are also irregular in respect to the level, to which the water will rise. The pressures are known of a few of the wells in the list given on page 314, and there is no evidence of regular decrease in pressure to the west. At Kelly's Camp the water rises with a pressure of 80 lb. to the square inch; while the adjacent well at Wanaaring, deriving its waters from about the same depth, and yielding water of the same temperature, has only a pressure of 10 lb. Again, the Warratta well, where the westward flow of the water would be dammed back by the old rocks of Mount Brown, does not flow at the surface, and its supply has to be obtained by pumping; although, so far as can be judged from Pittman's section, the surface-levels of the flowing wells at Tinaroo and Warratta are about the same. This series of wells does not agree in its details with what we should expect to find, if the water rose, owing to the simple pressure of the water in the Eastern Highlands.

3. Chemical Composition of the Well-Waters

The chemical composition of the well-waters does not afford any convincing evidence in favour of the artesian theory. On that theory we should expect the water to increase in salinity fairly regularly, as it flowed to the west. The chemical nature of the waters is best known in regard to the wells of Queensland.

The well which is richest in common salt—the constituent that is most likely to be dissolved from ordinary marine sediments—is at Maria Creek, to the east of the artesian basin. It contains 576 grains of salt per gallon, and it is also one of the richest in solid constituents. As we go westward, we find that, speaking generally, the waters contain less rather than more salt. The Normanton bore is an exception; but it lies close to the sea, and may thence gain its high salinity.

Moreover, the nature, as well as the amount, of the dissolved constituents varies irregularly in the wells of the Central Basin. The two chief constituents are carbonate of soda and common salt (sodium chloride); but their distribution is irregular. Thus in the group of four wells near Barcaldine,[1] those in the town give 63·7 and 66·5 grains per gallon of solid constituents, which is all carbonate of soda, with only traces of sodium chloride; while the well at Brixton, a few miles to the west, contains 83·5 grains of solids, of which

[1] Fifteenth Ann. Rep. Hydr. Eng., Brisbane, 1899, . 31.

81·42 are sodium chloride, and there is only 1·04 grains of sodium carbonate. Richardson's well, south of Barcaldine,[1] contains but 20 grains per gallon of solids, including only ·65 of a grain per gallon of sodium chloride.

Similar irregularities occur in other localities. The Kulki bore at Woolerina, with its 206 grains per gallon of solids, yields no sodium chloride, 57·6 grains per gallon of sodium carbonate, and 30 grains of some volatile constituent (other than carbonic acid). The chief material in the water of the wells on the Bowen Downs is carbonate of lime; and in the wells in the basalt area near Hughenden, the water contains much carbonate of of magnesium. The map opposite page 314 shows the variations in salinity of the chief artesian waters in the Central Basin. The waters are especially rich in solid constituents in four centres; at the head of Cooper's Creek, there is a large area where all the wells contain over 60 grains per gallon. Around 26½° S., 146° E., there is an area with over 70 grains per gallon. Near Mount Brown, at the western edge of the New South Wales artesian area, there is a group of wells giving over 100 and 200 grains per gallon. In the north-west, east of the Cloncurry Goldfield, there is an area with wells containing over 60 grains per gallon. Various isolated wells yield exceptionally high amounts. Thus at Cuttaburra (about 144½° E. and 29½° S.) the water contains 397 grains per gallon.

[1] Fifteenth Ann. Rep. Hydr. Eng., Brisbane, 1899, p. 33.

The general evidence, as shown by the lines of equal salinity on the accompanying map is that, going from the assumed intake near Charleville, the waters become less saline to the south-west, instead of becoming more so, as they should do, if the water were flowing south-westward from the intake. And in the area between Cloncurry and Glenora, the saltest water occurs on the western edge of the artesian basin, and it becomes fresher in the wells to the north, east, and south.

The irregular variation in salinity of these wells is also illustrated by the line of wells in New South Wales between Moree on the east and Milparinka on the west. The wells are enumerated in the following table, with the amounts of solid constituents in each gallon of their waters:

	Total solids in grains per gallon.	Sodium Carbonate.	Sodium Chloride.	Depth in Feet.	Temp. F.	Pressure in lb.	Yield in gallons per day.
Moree . .	49·78	39·26	7·03	2,792	115°	94	1,100,000
Wallon . .	78·68	58·72	15·80	3,747	124°	...	800,000
Bulyeroi . .	54·71	45·32	6·27	2,424	116°	...	1,750,000
Mooramina .	56·15	45·56	7·25	2,271	107°	...	1,069,000
Whitewood Bore		no	water				
Corella 1 . .	46·34	27·81	8·73	943	96°	...	368,000
Corella 2 . .	50·32	...	...	1,112	92°	...	156,000
Corella 3 . .	56·87	...	...	1,327	102°	...	240,000
Kelly Camp .	35·08	16·87	5·73	1,577	112°	80	600,000
Wanaaring .	50·63	35·79	10·39	1,644	116°	10	400,000
Osacca . .	73·51	56·51	11·37	1,646	129°	...	350,000 (flow ceased)
Clifton . .	125·83	98·18	21·48	1,638	139°	...	1,500,000
Tinaroo . .	205·91	...	...	1,858	139°	...	800,000
Warratta . .	202·12	16·67	150·17	2,393	...	...	pumping supply

These wells occur within the latitude of 29° and 30°; they extend in an irregular line about

500 miles long. The surface falls about 330 feet in the first 240 miles, and then 50 feet in the last 250 miles. The above table shows that these wells are not so regular in their behaviour as might be expected on the ordinary artesian theory. If all the water from these wells fell on the eastern hills, and be flowing thence to the west, we should expect to find it gradually becoming more saline as it flows westward; but, with the exception of the three westernmost wells, whose high salinity may be explained by their high temperature, the second well on the east is the most saline. The water with the least salt is at Kelly's Camp, about half-way along the series. Moreover, in this series, the hottest water does not come from the deepest wells. The water of the Clifton and Tinaroo wells is of the temperature of 139°, whereas the deepest well of this series is at Wallon, and its water is only 124°, and the well at Moree, 2,792 feet deep, has a temperature of 115°.

The chemical composition of the Australian artesian water suggests that much of it is derived from a plutonic source. For instance, the alkaline well near Charleville, with its high percentage of soda and potash, agrees in character with recognised plutonic waters in other regions of the world; and it is significant that this alkaline water occurs near one of the two regions of high pressure.

Some of the flowing wells in the artesian area of New South Wales are classed by Mr. Pittman as "mineral waters." Thus the water known as Zetz

Spa, found in the Talbragar Valley, north-east of Dubbo, comes up through a bore-hole; and there is no obvious reason, why it should be placed in a different category from some of the artesian waters. It contains 224 grains of solids per gallon, including 183 grains of bicarbonate of soda[1]; but the artesian wells of Cuttaburra, in New South Wales, yield water with 396 grains of solids per gallon.[2] Similarly, the water of the Normanton bore, in Queensland, yields 275 grains of solids per gallon, including 160 grains of sodium carbonate; while the mineral water of Helidon Spa yields 212 grains per gallon of that salt.

The Queensland well-waters give clear evidence of being in part of plutonic origin. The wells at Helidon Spa, containing lithium carbonate, are natural aerated waters; and they occur on the possible outlet, from the artesian basin to the South Pacific, near Brisbane. The well of Toowomba, in the same district, yields 2·55 grains per gallon of zinc. Some of the artesian wells in the artesian basin are alkaline springs, such as the well at Dillalah, with its 21 grains per gallon of soda and 19 of potash. The well at Oxton Downs, on Manfred Downs Resumption, derives its waters directly from a crack in the granite. Many of the well-waters are rich in carbonate of sodium, such as that at Boort, near Cunnamulla, which contains a total of 1,261 grains of solids per gallon.

[1] Pittman, *Mineral Resources of New South Wales*, p. 449.
[2] *Ibid.*, p. 475.

That the well-waters of Central Australia are partly of plutonic origin is also indicated by their temperature, which is often much higher than we should expect, if they were meteoric waters flowing along the beds pierced by the wells. The average increase of temperature below the surface of the ground is generally taken as 1° F. for every fifty-three feet in depth. Some authors maintain that this rate is excessive, and that the rate of 1° F. for every eighty feet is the true average. But many of the flowing wells in Australia show the rate of 1° F. for every twenty-two feet. This high temperature indicates, that the water has probably come from a much greater depth than that of the water-bearing layer. It is, therefore, more likely to be plutonic than meteoric water, as is certainly the case in the well at Oxton Downs, and in the hot springs of the Lower Flinders.

4. Gas Pressure in the Artesian Waters

The association of compressed gas with the artesian waters has been denied or doubted, but it is admitted that many of the well-waters smell of sulphuretted hydrogen, when they are first drawn.[1] Many of the Queensland well-waters are charged with carbonic acid, as is also the well at Ballimore, near Dubbo, in New South Wales. The most conspicuous case of the artesian waters being

[1] E. F. Pittman and T. W. E. David, "Irrigation geologically considered, with special reference to the Artesian Area of New South Wales," *Proc. Roy. Soc. N. S. Wales*, vol. xxxvii., 1903, p. cxxx. The fact is shown by the analyses for some Queensland wells.

gas-charged is at Roma, east of Charleville, in the chief, high-pressure area. The water there issues from some grey, sandy shale at a depth of about 3,680 feet, and in August, 1901, it gave off natural gas to the extent of 44,685 cubic feet a day. In February, 1904, it was measured by Mr. Henderson, when the gas-supply from the well was 70,000 cubic feet per day, and as an illuminant, it was of 24 candle-power. The gas is now being used to light the town[1].

Carburetted hydrogen occurs also in the Brisbane well; firedamp at Maria Creek; "a considerable quantity of free gas and dissolved gas under pressure escaped," with some petroleum, from the bore at Westlands Run. Gas or petroleum has also been found in the wells on Alice Downs at Bimerah; the Portland Downs; at Rockwood, where the Glenariffe bore gave off a "very large flow of firedamp-gas;"[2] and at Warbreccan.

The Mound Springs, which are generally regarded as natural artesian wells, mostly discharge carbonic-acid-gas. Those of the Lower Flinders yield water of the temperature of 120° F., and, as Professor David remarks,[3] they arise from granite.

5. The Feeding of the Wells

(a) *The Inadequacy of the Blythesdale Braystone*

The idea of the geological structure of south-eastern Australia, on which the original artesian

[1] Twentieth Ann. Rep. of Hydraulic Eng., Brisbane, 1904, pp. 1-2.

[2] Seventeenth Ann. Report of Hydraulic Eng., Brisbane, 1904, p. 69.

[3] T. W. E. David, "Artesian Water in New South Wales," *Journ. R. Soc. N. S. Wales for* 1891, vol. xxv., p. 294.

theory was based, has been greatly changed, as belief in the continuous water-bearing layer from Queensland to the Great Australian Bight has been generally abandoned. There has been a marked change, moreover, in the knowledge of the geological structure of the country along the intake line. According to Jack, the water worked its way south-westward through beds of Blythesdale Braystone, which was thought to occur all along the eastern area of the artesian basin, and to extend thence westward under the whole of it. But Pittman has shown that the Blythesdale Braystone does not occur in New South Wales; and probably it is a very local deposit, and does not extend beyond a short distance to the west. The only possible intake-beds in New South Wales belong to the Jurassic[1] system. And these rocks are far less favourable to the simple artesian theory than the Braystone, which, according to Jack, consists of loose sand-rock, which is so porous, and has so little cement, that, on being saturated with water, its grains fall apart into a heap of sand.[2]

The Jurassic rocks, according to Pittman and David, will absorb 12½ per cent., and even 25 per cent. of water. But the specimens of them which I have seen, though no doubt very absorbent, would not pass on their water readily

[1] The beds are accepted as Jurassic instead of Triassic, in deference to Mr. A. C. Seward's opinion as to the age of their characteristic fossil.

[2] It was called "Braystone" from its resemblance to the friable sandstone so named in the west of Scotland, which is there used for scrubbing.

like the Braystones, and would thus make a far less efficient subterranean channel. The resistance of friction caused by the passage of water would be much greater.

In some cases, as at Roma, the artesian water is derived, not from sandstones, but from shales, which, even when sandy, are practically impermeable to water, though water can be squeezed out of them by heavy, local pressure.

The inclusion of the Jurassic rocks as part of the water-bearing layer, was rendered necessary by the inadequate extent of the porous Braystone. Professor David [1] pointed out in 1893 that the outflow from the wells of New South Wales was then 3,000,000 gallons a day greater than the estimated inflow. As the intake was, therefore, too small to nourish the wells, he greatly increased its estimated area.

No doubt these Jurassic "sand-stones" will absorb water freely, like the English chalk; but, like that rock, they probably give it up slowly. The deep wells in the chalk are dependent on the water flowing freely through the fissures. If a well does not strike such fissures, galleries have to be driven through the chalk to reach them. But in these Jurassic shales and sandstones of Australia there are probably no such fissures. The water-bed is all charged with water, which escapes under high pressure as soon as a vent is opened.

[1] T. W. E. David, "Notes on Artesian Water in New South Wales and Queensland," *Journ. R. Soc. N. S. Wales*, vol. xxvii., 1893, p. 418.

Dr. Jack has pointed out[1] that there are no underground water-channels in Queensland. "There would," says he, "be a hundred unsuccessful for one successful bore if the artesian water ran in narrow underground channels instead of being almost everywhere present within the area represented by the outcrop of the Lower Cretaceous."

(b) *Percolation and Evaporation*

The calculations based on the artesian theory, as to the permanence of the flowing wells, require serious revision, in regard to the proportion of the rainfall that is available to feed the deep wells. A large intake is an essential requirement of the artesian theory. Russell's predictions were based on the expectation, that the rivers would carry off a much larger proportion of the rainfall than rivers usually do. According to Beardmore, some of the English rivers—such as the Thames, the Severn, and the Medway—carry off less than 12 per cent. of the summer rainfall. A river-discharge of 6 per cent. in the latitude and in such a climate as that of eastern Australia is by no means abnormally low. Thus it is estimated for the Transvaal[2] that, with a rainfall of 25 inches, the percentage of run-off to rainfall will be 10 per cent. in a good catchment, 7½ per cent. in an average catchment, and in a bad catchment

[1] R. L. Jack, "The Submarine Leakage of Artesian Water," *Proc. Roy. Soc. Queensland*, vol. xii., 1897, p. 64.

[2] W. L. Strange, Transvaal, Dep. Irrig. and Water-supply, Bull. No. 1, p. 4.

only 5 per cent. Pittman and David, in the last of their important contributions to our knowledge of the artesian wells of New South Wales, calculate that at least 20 per cent. of the rainfall of 25 inches should percolate underground. This estimate seems to me optimistic. The only satisfactory estimate of the amount of percolation is the difference between the total rainfall and the sum of the run-off in the rivers and the evaporation. Evaporation in such countries as the interior of New South Wales, Queensland, and South Australia is exceptionally heavy. These countries are either tropical or sub-tropical, so that their temperatures are high. The wind which sweeps across the central plains has dropped its moisture, as rain, on the highlands near the coasts; so that the air which travels across the plains is dry and thirsty, and absorbs an unusually large amount of moisture.

Evaporation will remove a much higher proportion of the rainfall in Central Australia than in such countries as France and England. It was at one time held in France that the evaporation always exceeds the rainfall; and though this view has not been confirmed, the fact that it was once the prevalent belief shows the heavy drain on the rainfall by evaporation, even in a moist, temperate climate. Moreover, the rainfall in Queensland does not occur under conditions favourable for percolation. The heaviest percolation in England takes place after snowfall, for then the upper layer of snow checks evaporation, and the lower layer

thaws gradually, and keeps the ground below sodden with moisture. Percolation under such conditions reaches its maximum. On the other hand, sudden storms of rain, falling upon a dry country and followed by spells of bright sunshine, are least favourable to percolation.

British evaporation may be illustrated by the records at Rothamsted, where the mean annual temperature is 48°, and the total annual evaporation from bare, drained soil is 16 inches, of which between 11 and 12 inches is lost in the six summer months. The rate of evaporation, it must be remembered, varies according to the nature of the surface. Thus at Rothamsted the annual evaporation, which is 16 inches for bare, drained soil, rises to 20 inches for a soil with crops growing on it, and 30 inches for a water-surface. The evaporation from a water-surface in Paris is between 51 and 59 inches.

At the Croton Waterworks, near Boston, U.S.A., the mean evaporation for six years was 39·21 inches, or 81 per cent. of the rainfall.[1] The probable evaporation in Queensland, as estimated by Vermeule's formula—

$$E = (15{\cdot}5 + {\cdot}16R)\ ({\cdot}05T - 1{\cdot}48),$$

taking R, the rainfall, as 22 inches, and T, the mean annual temperature, as 75°, would be 43 inches a year, or nearly twice the rainfall.

[1] D. Fitzgerald, "Evaporation," *Trans. Amer. Soc. Civ. Eng.*, vol. xv., 1886, p. 617.

The rate of percolation has been carefully investigated in many English localities. The Royal Commission on London Water-supply concluded that in the Lea Valley, from a rainfall of 26·5 inches, only 3·4 inches percolates into the ground, though there is much open gravel in the Lea Valley. At Rothamsted, in a year when the rainfall was 31·04 inches, the percolation amounted to 13·95 inches, of which 9·44 went through the percolation-gauge in the five winter months, and only 4·51 during the seven warmer months.[1] The careful percolation-experiments of Mr. Charles Greaves, at the East London Water Company's reservoirs at Lea Bridge, show that the rate through ordinary ground, for the mean of 22 years, has been 26·57 per cent. of the rainfall; but this percolation nearly all occurred in winter. In the summer, when the climate would still be colder than that of Queensland, the percolation often stops for months together. "For many consecutive months there is often no percolation whatever," says Greaves. "Five times there has been no percolation for seven continuous months, and twice none for six months, and only in one year, 1860, has there been percolation every month."[2] "Heavy rains in summer," he adds, "may afford no percolation." As men-

[1] A. P. Folwell, *Water-supply Engineering*, 1900, p. 91.

[2] C. Greaves, "On Evaporation and Percolation," *Proc. Inst. Civ. Eng.*, vol. xlv., 1876, pp. 24-26. In the discussion on this paper, Gilbert, Homersham, Field, and Sir J. Evans all thought that Greaves had exaggerated the percolation.

tioned above, the main percolation takes place during the winter, especially after falls of snow. In Central Australia there is no snowfall; so that even the winter in Australia is as unfavourable to percolation as the summer in the British Isles; and most of the rainfall in Central Australia occurs in summer, when the chances of any percolation are smallest. In countries such as California, which have a climate similar to that of Australia, evaporation would get rid of more rain than falls there, and much more rain than ever falls in Central Australia. Folwell, *e.g.*[1] quotes the case of Yuma, in Arizona, where evaporation would get rid of thirty times as much rain as falls in that locality. It is not surprising, therefore, that the measured evaporation-rates in Australia are enormous. Sir Charles Tod tells me that the nearest evaporation-tank to Lake Eyre records an annual evaporation of 100 inches, and that amount is accepted by the Victorian Water-supply Department for the evaporation in the dry north-western districts of Victoria.[2] Thus, from a free water-surface in Lake Eyre the evaporation is equal to from fifteen to twenty times the rainfall.

The depth below the surface at which water is safe from evaporation is a subject upon which there is a great difference of opinion. The depth varies

[1] A. P. Folwell, *Water-supply Engineering*, 1900, p. 117.

[2] H. C. Russell gives 65 inches as the annual evaporation in the western districts of New South Wales. In a letter to Dr. Jack, quoted in the *Proc. Roy. Soc. Queensl.*, vol. xii., 1897, p. 62.

under different conditions. During the English drought of 1902, the crops on the chalk hills of Kent were nurtured by water, which must have been sucked up by capillarity from a depth of probably 200 feet. So that in close-grained beds of uniform texture, water that has gone downward in one season may be sucked up again, in a succeeding spell of dry, warm weather. The assumption, that twenty per cent. of the rainfall on the western slopes of the hills of Queensland and New South Wales percolates underground, appears excessive. In what proportion of the area percolation is taking place, it seems at the present time impossible to say. The areas where evaporation exceeds the rainfall, and there is no percolation, could no doubt be determined by a survey of the soils. And the wide distribution of efflorescent soils in the arid regions of Central Australia shows that evaporation there exceeds the rainfall. Water is being sucked up from below the ground, and the salts brought with it in solution are deposited in a layer of efflorescent soil, sometimes as calcareous tufa, sometimes as ironstone, at others as a crust of chert.

In many cases, in ordinary, open country, no rain at all will percolate. It is only under special conditions, where the rain falls or rivers flow over beds of coarse, open sandstone, that much permanent percolation is likely to take place. Water from the rivers soaks into the banks; but most of this is returned to the air by evaporation, and we

cannot expect a high percentage of the rainfall to percolate from the rivers, as they themselves receive so small a fraction of it.

The view that evaporation is quite sufficient to account for all the rainfall of Central Australia that is not discharged by the rivers, and that there is no need to assume any percolation to account for its disappearance, has been urged by several Australian geographers.[1] The Government Engineer for Water-conservation in New South Wales, Mr. H. G. McKinney, answers the question, "What becomes of our rainfall?" by "Evaporation." He considers the case of Narran Water, from which the evaporation is probably six feet per annum. "But," he says,[2] "even if it were reduced by half, evaporation—and absorption by vegetation—would account for the disappearance of the entire supply carried into the lake." In a report on the Macquarie River, McKinney expressed the opinion that very little loss—at least when the river is low—is due to percolation. "It is," he remarked,[3] "in fact unlikely that any considerable proportion of the waters of our western rivers is lost by percolation, excepting in the higher parts of their courses; for the natural

[1] J. P. Thomson, "The Alleged Leaking of Artesian Water," *Proc. R. Geogr. Soc. Austral.* (*Queensland Br.*), vol. xi. 1895-96 (1896), p. 68. "The Climate and Artesian Waters of Australia," *Queensl. Geogr. Journ.*, xvii. (1902), p. 26.

[2] McKinney, "Rivers of New South Wales," *Rep. Austral. Ass. Adv. Sci.*, vol. i., 1887, p. 400.

[3] *Ibid.*, p. 399. See also J. P. Thomson, *op. cit. Queensl. Geogr. Journ.*, vol. xvii., p. 24.

tendency of a river flowing through alluvium is to tamp up [fill up] all interstices in its channel."

6. Tidal Artesian Wells

One type of well which has hitherto resisted all attempts at explanation on the ordinary theory, is that in which the water has an intermittent rise and fall, like the ebb and flow of a tide. The best known of these wells in Australia is at Urisino, in New South Wales.[1] It is a sub-artesian well, the water of which rises into a tank, from which it is pumped to the surface; this water has a regular rise and fall. Unfortunately this well is in a very inaccessible position, so that its investigation is beset with special difficulties; but, thanks to the exertions of Mr. Pittman, a time-gauge has been placed on the well, and records have been kept on three occasions. The ebb and flow of the well varied from 16½ to 18 hours in November, 1894; from 8 to 12 hours in May, 1896; and from 8½ to 12 hours in March to May, 1897. None of these periods agree with that of an ordinary, lunar tide; so that we cannot attribute it to a tide in the water or in the atmosphere. Un-

[1] Short references to this well have been made by Henderson (Ann. Rep. of Hydraulic Eng. on Water-supply, 1895, p. 4). Also by David, "Notes on Artesian Water in New South Wales and Queensland," Part II., *Journ. R. Soc. N. S. Wales for* 1893, vol. xxvii., p. 429. The most detailed account is in Pittman and David, "Irrigation geologically considered, etc.," *Journ. and Proc. R. Soc. N. S. Wales*, vol. xxvii., 1903, pp. cxxxi-cxxxiii, pl. xxiii., xxiv. On asking Mr. Pittman for information about this well, he kindly gave me a copy of the tide-records, which have since been published by himself and Professor David.

fortunately we do not know whether the rise and fall of water is accompanied by any variation in temperature, or in the chemical composition of the water. But such variation is not improbable; for, according to Henderson,[1] some of the wells vary regularly in temperature for several degrees, and in pressure for several pounds; and it has been frequently remarked that the well-waters, when first drawn, smell unmistakably of sulphuretted hydrogen. No explanation has yet been offered as to the cause of the movements in the Urisino well.

Tidal wells are known in many parts of the world. They are frequent on low coastlands; and such wells can be satisfactorily explained as due to the damming back of water, flowing seaward from the land, by the rise of the tide on the shore. An interesting tidal well, at Tarkoo in the Karroo, South Africa, at the height of about 2,700 feet above sea-level, has been investigated by Professor Andrew Young, of Capetown.[2] It is one of a group of five, shallow, artesian wells, and shows a regular tidal ebb and flow of about two inches. The well gives off quantities of marsh-gas and sulphuretted hydrogen; but in this case, as the tidal period is about twelve hours twenty-eight minutes, it agrees with that of the ordinary lunar tide. This well, moreover, shows a well-marked

[1] J. B. Henderson, Ann. Rep. Hydraulic Eng. on Water-supply for 1896, Brisbane, p. 4.

[2] For the above details I am indebted to Prof. A. Young.

difference between the spring and neap tides, the rise and fall being greater at full moon; so that in this case the ebb and flow is no doubt due to the influence of the moon.

The movement in the Urisino well must have a very different cause. It probably belongs to the same category as the well at Jaude, in Clermont, which, as described by de Launay,[1] has a regular rise and fall at intervals of five minutes, due to the escape of carbonic acid gas. Another oscillating well is described by Daubrée, at Montrond,[2] on the Loire. Its water rises in periodic paroxysms, with intervening periods of depression. The rise of the water in the well-known flowing wells at Nauheim and Kissingen, in Germany, are also due to pressure of included gases.

Geysers are allied phenomena, and their eruptions sometimes recur regularly for long periods. Thus the Old Faithful Geyser of the Yellowstone Park, for years burst into eruption every fifty-nine minutes; but the period has lengthened, until its eruptions now occur at irregular intervals, which are usually between seventy and ninety minutes in length. We do not know enough about the water in the Urisino well, for any reliable suggestion to be made as to the precise cause of its oscillations; but it agrees far more with periodic geysers, and with oscillating wells—such as that at

[1] Described by de Launay, *Recherche, Captage, et Aménagement des Sources Thermo-Minérales*, 1899, pp. 196-197.

[2] Daubrée, *Les Eaux Souterraines*, vol. i., pp. 369-375.

Jaude—than with any well supplied by meteoric water.

The Urisino well is not by any means the only tidal, artesian well in Australia. Professor David,[1] in his paper of 1893, says, on the authority of Mr. Boultbee, that the well at Ninety-one Miles has a tide of four feet rise and fall, every four hours. Henderson reports[2] with regard to the bore at Westland, that from the beginning of 1898 to the middle of 1899 "there were great pulsations in the evolution of firedamp, at intervals of a few seconds, which have now nearly disappeared; temperature stated to have been 6° F. higher." The well on the Fernlee Run has a daily tide of two inches.[3] The Maria Creek well has an intermittent flow, which Henderson attributes[4] to gas pressure, and says that firedamp was discharged from the well.

V. THE ASSUMED PERMANENCE OF THE SUPPLY AND THE DANGER OF THE PRESENT WASTE

I long hesitated before finally rejecting[5] the ordinary artesian theory of the Central Australian wells, in face of its acceptation by such authorities as Jack of Queensland, Pittman and David of New

[1] T. W. E. David, "Notes on Artesian Water in New South Wales and Queensland," Part II., *Journ. R. Soc. N. S. Wales for* 1893, vol. xxvii., p. 429.

[2] Seventeenth Ann. Rep. Hydr. Eng., Brisbane, 1901, p. 71.

[3] Henderson, *Ibid.*, p. 70.

[4] *Ibid.*, p. 69.

[5] I expressed doubts on the subject first in a lecture at Bendigo on the "Variation of Ores in Depth," in March, 1901, reprinted by the *Chamber of Mines*, Melbourne, and in *Australian Mining Standard*, vol. xx., 1901, pp. 1002-3.

South Wales, and J. W. Jones of South Australia. My return from Australia prevented my undertaking further visits to the artesian areas and from making further tests. The importance of determining the true nature of these wells is my excuse for advancing my opinion, although it differs from the authorities, whose judgment I so greatly respect. The question is not merely one of settling a theoretical explanation. It has an important practical bearing. Many of these wells now run to waste. We saw, for example, the well at Dulkaninna pouring its million gallons a day into a dry, creek bed; its water is all lost by evaporation, and, in fact, most of it does more harm than good; for it is impregnating some rich, fertile soil with a deposit of carbonate of soda.

This waste is defended on the ground, that the water is being renewed at a rate which so vastly exceeds the outflow from the wells, that they will last for ever without any diminished flow. The discharge from all the wells is said to be "a mere bagatelle" compared to the amount poured in from the rainfall; and the wells are said to be quite "insignificant" in comparison to the leakage into the sea.

Strong protests have, however, been made against the present waste of water. Mr. Henderson, the Hydraulic Engineer to the Queensland Government, declared in 1893[1] that the "injudicious and wasteful use of the water" should no longer be

[1] Rep. Hydr. Eng., Brisbane, 1893.

allowed; and he said there was "a strong element of danger" in such waste. He suggested the possibility that even then "the output of the wells may exceed the inflow, and that the output is maintained by accumulations of water stored in the porous beds." Sir Hugh M. Nelson[1] has issued the warning that some wells have ceased to flow, "others have dwindled down to an insignificant volume, and there is no guarantee that they will not sooner or later cease to flow, and that others will not follow suit."

Legislation to stop this waste has twice been proposed. A Bill was carried through the Queensland Legislative Assembly in 1891; but the Legislative Council rejected it. In New South Wales a similar Bill was proposed in 1894, which would have authorised the Water-conservation Department to order the partial closing of the wells; but it also failed to pass.

The Solicitor-General, the Hon. T. J. Byrnes, in introducing the Queensland Bill, declared that the water "has been allowed to run to waste in a scandalous manner, and if that is permitted, the artesian supply will give out in time."[2] The rejection of the Bill was, apparently, mainly owing to the strong objection to section 14, which proposed "That the Minister shall have power to serve a notice requiring a person to fit his artesian

[1] *Queensland Geog. Journ.*, vol. xvii., 1902, p. 149.

[2] Queensland Parl. Debates, Legis. Council, June 13th to Nov. 13th, 1891, vol. lxiii., p. 221.

bore with such valves, pipes, etc., as will effectually prevent the water from running to waste; and if he neglects to do so, there is a provision for a substantial penalty." This section had been introduced on the advice of the professional head of the Hydraulic Water Department in Queensland; but it was opposed, amongst others, by the late Sir A. C. Gregory, formerly Surveyor-General of Queensland. He declared that "the idea of exhausting our artesian water-supply is something like the fear that if we were to draw water from the ocean we should sensibly affect it."[1] And later on he declared[2] that the loss of the artesian water by leakage into the sea is so great, that the waste from the wells is inappreciable. One member of the Legislative Council opposed the stopping of the waste on the ground, that "whether the supply is inexhaustible or not can only be proved by allowing the water to run"; and he preferred to exhaust the supply rather than remain in doubt as to its extent.

The opinions on which these Bills were rejected do not seem to me justified by the facts. If these wells are not truly artesian, or if the proportion of the rainfall available for their renewal has been much exaggerated, then these conclusions are invalid, and the existing waste of water is deplorable. The amount of water may remain undiminished

[1] Queensland Parl. Debates, Legis. Council, June 13th to Nov. 13th, 1891, vol. lxiii., p. 228.
[2] *Ibid.*, p. 254.

for years, though many of the wells already yield less than formerly.

Amongst other bores which give a reduced flow, Henderson, in his Annual Report for 1901, enumerates the following:

Barcaldine	Bowen Downs
Afton Downs	Charlotte Plains
Brackhill	Coreena
Halfmoon	Dalzell
McLachlin's	Elmina
Jacondool	Saltern Creek
Dunraven	Tara
Boorara	Westland

It has been suggested that the diminished flow is due to the choking of the bores; but the phenomena appear too widely spread for this explanation, which will certainly not apply in some cases, as at Pera, near Bourke, in New South Wales. The diminished flow in that well was thought to be due to a partial closing of the bore; so it was cleared out, but without restoring the old flow. A second bore was then put down, and it yielded convincing evidence of the diminished water-pressure. The lesser supply of water has also been attributed to the drought; but the variations appear to be too irregular and too local for such a general cause, which would have affected the north-eastern bores first, and subsequently those farther to the south-west.

There may be no immediate prospect of the wells running dry; but it is not safe to assume that they will flow on for ever.

VI. SUMMARY

These Central Australian wells may be called "artesian," in consequence of the general extension of that term to any flowing wells. But the view, that the ascent of the water in them is due to the pressure of water in the Queensland hills, does not seem to me to be any longer tenable. The responsibility for this view rests with the meteorologists. It was originally based on a 75-per-cent. under-estimate of the discharge of the Darling River, a 300-per-cent. over-estimate of the discharge of the Murray, and a large exaggeration of the estimated proportion of the rain, discharged by rivers in general.

These estimates, of the ratio of river-discharge to the available rainfall, led to an exaggerated estimate of the amount of rain-water that percolates underground, based on an under-estimate—in spite of the protests of the engineers—of the amount of evaporation. Such miscalculations were easily made thirty years ago, with the limited knowledge of Australian meteorology then available; and the conclusions as to evaporation and percolation, based on them were naturally accepted by geologists.

In 1881 the data regarding the geology of eastern Central Australia were limited; but, with fine scientific insight, Dr. Jack recognised its basin-shaped structure, and the geologists of Australia—in spite of their small numbers and the

vast areas they had to survey—determined, with complete success, the limits within which these deep waters could be found. The great extension of the possible sources of supply in Queensland and New South Wales was indicated by Pittman and David, who showed that Jurassic sandstones were even more important, as water-bearing beds, than the Blythesdale Braystone. The simple arrangement of the bedded rocks of Central Australia gave the wells a regularity, which helped the general adoption of the simple artesian theory. During the last twenty years a great accumulation of evidence has been collected, owing to the far-sighted policy of the Governments of Queensland, New South Wales, and South Australia, and the skill of their officials, including Mr. J. W. Henderson, of Queensland; Professor David, Mr. Pittman, and Mr. Boultbee, of New South Wales; and Mr. J. W. Jones, of South Australia. It is now possible to feel the pulse of the subterranean waters over most of the artesian basin, and its throbbing shows that the rise of the waters is due to a more complex cause than was, at first, suspected.

The ordinary official theory has not by any means been accepted without protest. Dr. Jack himself was at first disposed to seek some other cause for the rising of the water than hydrostatic pressure. He said, in 1892, that "in the case of the Queensland wells it is doubtful if the strata in which the water has been tapped crop out at

elevations sufficient to give the pressure required to raise the water to the surface."[1] He remarked that "even if the water had to pass through an iron pipe, there would still be such a loss by friction in two or three hundred miles, that it could not rise quite to the level of its source," and he explained the ascent of the water as due to its expansion, assisted by the elasticity of the imprisoned gases.[2] Considering the amount which could be collected from the then assumed intake-area, he thought that the use of the water should be restricted to stock and towns. "Even irrigation," he said, "I should regard as wilful waste, unless indeed, after the lapse of years, there should be found to be no diminution in the supply."[3]

Mr. Russell tells us[4] that engineers and squatters, who knew all the country, protested against his views, and told him positively, that the rain would not furnish any underground supplies, and that whatever got into the ground was all lost again by evaporation.

Dr. Jack's earlier opinions and the protests of engineers have been swept away by the fascination of the simple, artesian theory, which has received almost universal, official acceptance. But the mass of evidence now available as to the distribution of the water, the variations and pulsations in

[1] Jack and Etheridge, *Geology and Palæontology of Queensland and New Guinea*, 1892, vol. i., p. 416.

[2] *Ibid.*, p. 417.

[3] *Ibid.*, p. 418.

[4] *Journ. R. Soc. N. S. Wales*, 1889, vol. xxiii., p. 57.

its pressure, and its chemical qualities has not confirmed the generally accepted theory. The chemical composition of the waters indicates clearly their mixed origin. Just as the Gulf Stream, which was supposed to continue from Newfoundland to Western Europe, was proved to be non-existent by H. N. Dickson's detailed analyses of the Atlantic waters, so the chemical composition of the well-waters of Central Australia show, that there is no proof of any regular current in its subterranean waters from the north-east to the south-west. The analyses also show that much of the water is probably of plutonic origin.

The high-temperature gradients indicate that the water often rises from great depths, and in one case, at least, it is known to be obtained from the underlying granite, and not from the bedded rocks, which outcrop on the eastern hills.

The occurrence of tides in the wells is unexplained on the ordinary theory. The tidal ebb and flow will generally pass unnoticed, except in sub-artesian wells, where the water-level is within a few feet of the surface of the ground; and probably many more of the wells are affected by the same pulsation.

That the tension of gases dissolved in the water —or of the water itself, when superheated—is an influence much greater than has been allowed for, is shown by the occurrence of free gases in so many of the artesian wells. The decreasing yield of the wells is another important indication of

their flow, from local stores of water. If the water is all of meteoric origin, it must be continually enlarging the underground fissures—for it brings up much mineral matter to the surface; but a decrease in the supply is reported from localities widely scattered over the artesian basin, and appears to be a more general feature than can be explained by the mere choking of the wells.

That the wells are discharging past accumulations of water is rendered more than ever probable, by the discovery, that there is no outlet from the deep, central basin of the Lake Eyre country to the south, to the south-west, or to the north. The fact that the main artesian basin has no regular outlet, and is enclosed by a rim which—so far as we know—is complete to the west and south, and has only a narrow, shallow lip to the north—and perhaps another to the east—shows that the deep, central waters are old accumulations. Whether the wells are flowing under the pressure of far-distant water, or under the local pressure of the overlying rocks and of their own dissolved gases, does not affect this question. They are the modern, artificial outlets from a vast reservoir, which is almost entirely closed, and the waters discharged from it must have collected during the course of centuries, and probably of past millenniums. Those politicians who—in 1891 and in later years—have proposed to stop the unnecessary waste of these waters adopted a sound

and safe view. Water is the raw material of which Central Australia is in most urgent need; Nature has stored up a vast—but probably a limited—supply in a safe, underground reservoir. That water, if prudently used, would probably last till Central Australia were so well occupied, that it could afford to provide a more costly supply. But to allow these deep-well waters—in obedience to a mistaken analogy as to their origin—to run heedlessly to waste, is a policy of which a later generation of Australians may have bitter cause for complaint.

CHAPTER XVIII

ON THE PROPOSAL TO FLOOD LAKE EYRE FROM THE SEA

The Earth is the Lord's, and all the corners thereof. He created the Mountains of Wales as well as the Wiles of Kent, the rugged Alpes as well as the fertile Plains of Campania—the boggy Fennes of Frizeland as well as the daintiest Valleys in France; and to enveigh against or deride a Countrey for the barrenesse thereof, is tacitly to taxe God Almighty of Improvidence and Partiality.

JAMES HOWELL, *Instructions for Forreine Travell* (Published 1642).

THE most enthusiastic of Australians admit that their climate is in some respects sadly imperfect, and the theory that the whole world is undergoing slow desiccation (pp. 153-4) threatens that Nature, if left alone, will make it worse. To improve the climate artificially would be a big undertaking, for Australia is a whole continent; but its people are not frightened by the size of a scheme, provided it promises adequate results. The worst of Australia is the partial distribution of its rainfall, whereby some regions are barren through drought, and others through a twelve-foot or even a seventeen-foot rainfall.[1] Hence it is difficult to

[1] Geraldton in 1894 had the generous allowance of 211·24 inches of rain (Fifteenth Annual Report on Water-supply, Queensland, 1899, Table in App. No. XI.)

discuss the leading facts of Australian meteorology without disobeying Howell's maxim. His injunction might, indeed, have been appropriately adopted as the motto of the Geographical Societies of Australia; for travellers there, especially in the central regions, are very apt to disobey it. It was well for Howell that he died before he had the opportunity of reading the literature of Central Australian travel, in which his principle has been steadily ignored. Man's attitude to Nature has changed since Howell's time, and we can now recognise the inequalities of existence without irreverence, and can attempt to rectify them without impiety. A traveller may now describe Central Australia as a heart-breaking wilderness, and may appeal to the engineer to remedy its wrongs, without protest against impudent interference with the intentions of the Almighty.

If there be one area more than another, wherein a man may be excused for wishing that he had been consulted as to the plan of the universe, it is that of the arid lowlands around Lake Eyre. There an "abomination of desolation" covers thousands of square miles of country, which has a soil of exceptional richness, an invigorating, bracing atmosphere, and a climate free from malaria and the special diseases of most sub-tropical lands. Given but water, that country would be as fertile as a garden; and if it remained as free from mosquitoes, malaria, and flies as it was during our

visit, it would be an Eden. But, owing to the scanty supply of water,

> And flaming noontides mute with heat,
> Beneath the breathless, brazen sky,

the land lies withered and wasted. The extermination of the old native game has removed the few people who knew how to live in the country, and it is too poor to repay the white man for the inconvenience of life, so far from his fellows. Various schemes for the improvement of Central Australia have been mooted; and the most daring of them is one, that proposes to secure for Central Australia a fairer share of the good gifts of the universe, by flooding the basin of Lake Eyre from the sea. This idea was an inevitable result of geographical theories. Sturt was sure, that the part of the Lake Eyre basin, which he reached in his expedition into Central Australia during the years 1844, 1845, and 1846, was the bed of an ancient sea. He saw in his "Stony Desert" the effect of a powerful, marine current sweeping across the floor of a sea; he attributed the long, loose sand-ridges, "which follow each other like the waves of the sea in endless succession," to the shifting of sand along a shore. Sturt concluded—"that the whole of the low interior . . . traversed was formerly a sea-bed, once raised from its submarine position by natural, though hidden causes."

Then followed the discovery, that part of Sturt's supposed sea-floor, even now, actually lies below

sea-level. The accurate surveys made for the Great Northern Railway of South Australia establish this fact beyond doubt. Stuart's Creek railway station, near the south-western corner of Lake Eyre, is three feet below sea-level; the southern shore of the lake is thirty-six feet lower; the centre of the lake is estimated to be sixty feet below the level of the sea.

Accordingly, the proposal was made to cut a canal from the sea at Port Augusta to Lake Eyre, and flood its vast basin with sea-water. Similar proposals have been made for other continents. An enthusiastic champion of the rights of aborigines advocated, in 1877, the flooding of the Sahara. The native inhabitants were not consulted, and the most serious opposition to the project was expected from the hotel-keepers of the Mediterranean watering-places, who feared the change might deprive them of their warm winter winds. Like the deserts of Central Australia, the Sahara was supposed to have been a recent sea-floor. Most of it, on the contrary, is a high, rugged tableland. Some depressions on the margin, however, were known to be below sea-level; so the rash assumption was made that a short and cheap canal, through some sand-dunes on the Atlantic shore, would turn the high plateau of the Sahara into a second Mediterranean Sea.

Possibly this proposal suggested the scheme of flooding the Lake Eyre basin, which was discussed in 1883; and the disastrous drought of 1901-2 has led to a revival of the idea. Mr. J. W. Jones,

formerly the Deputy Surveyor-General for South Australia, and now Secretary of the Public Works Department of the state, reported that the scheme was impracticable.

The distance from the centre of Lake Eyre to Port Augusta is two hundred and sixty miles, and the lake-surface is thirty-nine feet below sea-level; so the fall in this distance is the low grade of an inch and a fifth to the mile. The water would, doubtless, flow through such a channel, and probably with sufficient velocity to keep it open. The Murray has a fall of about two inches to the mile in part of its lower course, and yet keeps its channel clear. So I see no physical impossibility in the flooding of the Lake Eyre basin. It would, however, be an expensive undertaking.

The size of the channel that would be necessary would depend on the amount of evaporation, and the channel must be large enough to keep pace with the loss of water from this cause. That this loss would be heavy is obvious, from the fate of the floods, which are carried into Lake Eyre by the Diamantina and Cooper. The quantity of water these rivers discharge into Lake Eyre is enormous. The Diamantina rushes along like a mill-race; the Cooper flows in a broad sheet, in places twelve miles wide; and both rivers sometimes flow for months. Nevertheless, though the southern part of Lake Eyre frequently holds water, no man has yet seen the lake either full, or nearly

full. And if these two large rivers cannot fill the Lake Eyre basin, a sluggish fifty-feet canal would be as successful, as a Melbourne water-cart trying to induce one of its broad thoroughfares to lie quiet in a dust-storm.

The size of an efficient channel can be calculated as follows: Sir Charles Tod has informed me that the evaporation-gauge belonging to the Meteorological Department of South Australia, nearest Lake Eyre, records an annual evaporation of 100 inches. Let us take it at a quarter of an inch a day. Lake Eyre is roughly 80 miles long by 40 broad; so, excluding the area of the southern lake, it covers 3,200 square miles. Suppose, to be on the safe side, that only 2,000 square miles of this area be flooded. The evaporation of a quarter of an inch of water from a square mile involves the loss of 3,630,000 gallons. So evaporation from the 2,000 square miles of Lake Eyre, would mean a daily loss of over 7,000,000,000 gallons, or more than 200 times as much as the daily consumption by Melbourne in the summer. The waters of Lake Eyre could not be maintained by a channel carrying less than 7,000,000,000 gallons a day.

Mr. A. S. Kenyon, of the Victorian Water-supply Department, has kindly calculated for me the size of the channel which, with a fall of $1\frac{1}{5}$ inch to the mile, would be required to make up the loss by evaporation, at this rate, for an area of 2,000 square miles. If the channel were ten

feet deep, it would have to be 1,000 feet wide.[1] A channel of this size would be a very costly affair, especially as the cuttings would have to be very deep, as well as long. The Lake Eyre basin is closed on the south by a ridge of hills, to the north of Lake Torrens. There is one low gap on the divide, at the height of 175 feet above sea-level. The shore of Lake Torrens itself is 111 feet above sea-level, and its bed is but little below this. Hence the channel would have to be cut to a depth of 100 feet for 200 miles, and in one place to 200 feet.

There is no insuperable, physical difficulty in such a work. Its practicability is a simple matter of expense. The cost of a 260-mile canal is heavy, even under the most favourable circumstances, and for a narrow channel. Mr. J. W. Jones estimated that a channel only fifty feet wide at the bottom, with sloping sides, and cut at the price of three shillings per yard, would cost over £37,000,000.[2] No estimate is possible for a canal large enough to be efficient; for a work on such a scale would disturb all existing prices, and revolutionise the industrial and political conditions of the state. But if a canal twenty times as large cost twenty times as much, then, on Mr.

[1] It is, of course, not suggested that this would be the best shape for the proposed canal; but these figures were the ones for which, with the hydraulic tables at hand, the calculation was most easily made.

[2] Canal from Port Augusta to Lake Eyre (Parl. Pap., South Australia, 1883, No. 88).

Jones's estimate, the scheme would mean an expenditure of £740,000,000. At three per cent. interest—and it is doubtful whether even the British investor would lend money for this scheme at that rate—it would involve an annual interest charge of £22,200,000. There would, moreover, be a heavy cost for maintenance. Even if the channel could be kept open for nothing, the lake-bed itself would have to be cleared, or in time it would be filled by the accumulation of silt and salt. The maximum depth of the lake, according to the best available data, would be about twenty-one feet. Most of the lake would be shallow, so we might take the probable average depth at about nine feet. Then, if the evaporation occurred at the same rate all over the lake as it now does in the nearest evaporation tank, and if none of the water were returned as rain upon the lake, the whole of it would be lost annually by evaporation. Every year there would be deposited, over the whole lake-floor, a layer of salt containing the total amount of material in nine feet of sea-water. The sea contains 3½ parts of salt in 100 parts of water; therefore 100 inches of salt water would deposit a layer—allowing for various details—of 3½ inches per annum. Thus in thirty years the whole lake-bed would be slowly choked by salt, like a natural salt-pan.

The chief benefit, that Central Australia might possibly obtain in return for the cost of this canal, would be an increase in the rainfall. Probably the

flooding of 2,000 square miles in Lake Eyre would ultimately have that effect. This increase would, however, be an indirect effect, and its amount might be small. The asserted connection of forestry and rainfall is not so simple and direct as is often thought. The water that falls as rain is derived from evaporation that takes place, often thousands of miles away, on the surface of a distant sea. The main rain-carrying clouds travel at so great a height, that they would probably not be seriously affected by even 2,000 square miles of water below them. The south-westerly winds crossing the lake would carry the moisture derived from it to the north-east, and increase the rainfall on the Queensland hills. The amount of local rain that would be derived from the surface of Lake Eyre would probably be a few showers.

The effect on the dew would be more important. The presence of this sheet of water would certainly lead to a lowering of the mean annual temperature in its neighbourhood. So much heat would be used up in the evaporation of the water, that the temperature would be lowered. At the same time the evaporation would make the air moister, and the consequence of these two conditions would be a heavier fall of dew than takes place at present.

The Murray is only a narrow thread of water, but it has a marked influence on the temperature of the belt through which it flows, and heavy dews occur along its course, for a mile or two back from the river. A good supply of dew will support a

very useful vegetation. The first effect on the rich loams round Lake Eyre would be to lead to a growth of turf. And as the turf grew, it would mat the loose sand together and deprive the wind of its power of shifting the soil. Sand-erosion at present kills any tree or shrub that is not case-hardened, or which has not a sufficiently elastic surface to throw back the sand-grains without being injured. In the date plantation at Lake Harry, the sand cuts deeply into the rough midrib of the palm-leaves, and no ordinary, soft-stemmed shrub or thin-leaved plant could live. But a cover of turf would stop this desert sand-blast. Plants, that have under present conditions no chance of success, would be able to replace the dry and hard-skinned vegetation. Accordingly, the grassy steppes would be able to support other trees and shrubs, than those of the desert Flora. Instead of such foliage as the narrow spines of the needle-bush (*Hakea*), or the thick-rind leaves of the desert-box, trees would grow with broader, thinner leaves.

The effects of this change would be decidedly beneficial to the country, and no doubt lead to the increased fertility of the shores of Lake Eyre. But how far this influence would reach, it is impossible to calculate, or even to guess approximately. There would be many subsidiary effects, some of which would increase, and some lessen, the good that would be done by the climatic change. But it would certainly not be safe to rely on a fundamental change of climate,

or on a great improvement, except close to the lake.

The existence of small, arid islands in the Indian Ocean, the barren shores of Southern Morocco, and the desert on the coast of Southern Peru show, that the mere proximity of even an ocean does not ensure a moist climate. The flooding of Lake Eyre might do as little good to Central Australia as the Dead Sea does to its barren basin. The new vegetation would help to regulate the amount of moisture in the atmosphere, for it would give out most on dry days, and absorb most on wet ones. It would tend to keep the conditions moister and indirectly increase the rainfall. The change in vegetation would at any rate secure a more effective use of the rain that falls. But the most that could safely be expected would be an improvement of the geographical conditions for some miles around the lake, obtained at a price which might pay, if the land were stocked with the sheep that grew a golden fleece.

APPENDIX I

LIST OF THE NEW FOSSIL BIRDS DISCOVERED WITH THE BONES OF THE KADIMAKARA. (DESCRIBED BY MR. C. W. DE VIS, "ANNALS OF THE QUEENSLAND MUSEUM," No. 6, PP. 3-20, PL. I.—IX.[1])

Taphætus lacertosus, n. sp. (a Short-legged Eagle). Kalamurina.

Asturætus furcillatus, n. sp. Loc. No. 5, Lower Cooper.

Baza gracilis, n. sp. Loc. No. 6, Lower Cooper.

Leucosarcia prœvisa, n. sp. Wurdulumankula.

Ocyplanus, nov. gen.

„ prœses, n. sp.

Xenorhynchopsis, nov. gen.

„ tibialis, n. sp. Lower Cooper.

„ minor, n. sp. Unduwampa; Wurdulumankula.

Ibis (?) conditus, n. sp. Wurdulumankula.

Archæocycnus, nov. gen.

„ lacustris, n. sp. Lower Cooper; Kalamurina; Wankamaminna; Unduwampa; Malkuni; Wurdulumankula.

Chenopis nanus, n. sp. (a Black Swan). Lower Cooper; Malkuni; Wurdulumankula; Unduwampa.

Biziura exhumata, de Vis (a Musk-Duck). Malkuni; East of Pirani.

Anas gracilipes, n. sp. Lower Cooper; Kalamurina.

„ (Nettium) strenua, n. sp. Patteramordu.

Nyroca effodiata, n. sp. Wurdulumankula.

Nettapus eyrensis, n. sp. Lower Cooper.

[1] The larger birds' bones found are not included in this list.

Pelecanus grandiceps, n. sp. Lower Cooper.
„ proavus, de Vis. Lower Cooper.
Plotus laticeps, n. sp. Lower Cooper.
Phalacrocorax gregorii, n. sp. Wankamaminna; Lower Cooper; Malkuni; Kalamurina; Wurdulumankula.
Phalacrocorax vetustus, n. sp. Malkuni; Kalamurina; Lower Cooper; Wurdulumankula.

APPENDIX II

NOTE ON THE MAMMALS COLLECTED, BY E. B. DOW, B.M.E. (MELB.).

Owing to the succession of dry seasons, life of any description was very scarce in this area; and it was found difficult to procure specimens, as the following list shows.

The Dingo seems to have withstood the rigours of the drought longer than other animals, for he ranged over the whole of the country traversed, and in many cases was found miles away from any known water.

The characteristic "nest" of *Conilurus conditor* was observed on several occasions; but though fresh tracks were always discernible, no specimens could be obtained.

Order.

I. Carnivora.
Canis dingo, Blumenbach (1780).

II. Chiroptera.
Nyctophilus timoriensis (Geoffroy) (1806), from Kilalpaninna, Kopperamanna, and the belts of timber lining the main watercourses.

III. Rodentia.
Conilurus mitchelli (Ogilby) (1838), from the sand-hill country between the rivers Diamantina and Kallakoopah.
Conilurus conditor (Gould) (1849), near eastern shores of Lake Eyre.

IV. Marsupialia.
Peragale lagotis (Reid) (1836), from sand-hills along Lower Cooper.

The last-mentioned specimen is an adult female, and as it is smaller in every particular than other adults described, its measurements are here given:

	Millimetres.
Length of head and body	340
Length of tail	196
Length of hind-foot	75
Length of ear	74
Muzzle to eye	52
Skull—Basal length	78
Greatest breadth	34·5
Nasals, length	37
Nasals, greatest breadth	3·3
Palate, length	45·5
Palate, breadth outside m^3	21·2
Palate, breadth inside m^3	13
Palatal foramen, greatest breadth	8·5
Palatal foramen, greatest length	15·5
Basi-cranial axis	32
Basi-facial axis	45
Teeth from front of canine to back of m^4	34
Horizontal length of p^3	3·2
Horizontal length of p^4	3
Horizontal length of m^{1-3}	11·5

APPENDIX III

A LIST OF ORIGINAL LITERATURE ON THE LAKE EYRE BASIN.

EXCLUSIVE OF REFERENCES TO THE AREA IN GENERAL COMPILATIONS AND TEXT-BOOKS; AND OF LITERATURE ON ARTESIAN WELLS, NOT DEALING EXCLUSIVELY WITH LAKE EYRE REGION, REFERENCE TO WHICH IS GIVEN IN PART III. SOME LITERATURE IS INCLUDED DEALING WITH THE STRUCTURE OF THE HIGHLANDS ON THE SOUTHERN MARGIN OF THE LAKE EYRE BASIN.

ANDREWS, F. W.:

1876. "Remarks on Specimens of Minerals and Fossils found near Lake Eyre." *Parl. Pap., S. Austral.*, 1876, No. 19, p. 42.

ANONYMOUS:

1861. "The Burke and Wills Exploring Expedition: an Account of the Crossing the Continent of Australia, from Cooper's Creek to Carpentaria, with Portraits and Biographical Sketches of Robert O'Hara Burke and William John Wills." Melbourne, 1861: 8vo, 39 pp.

1893. "Analysis of Mineral Waters in the Far North." *Parl. Pap., S. Austral.*, 1893, No. 67: 1 p. and table.

1895. "The Desert Sound," by "Baldag." *Austral. Mining Stand.*, 1895, vol. ix. p. 312.

BABBAGE, B. HERSCHEL:

1858. "Northern Exploration. Further Correspondence respecting the Exploring Party under Command of Mr. Babbage." *Parl. Pap., S. Austral.*, 1858, No. 25*: 6 pp.

1858. "Petition of B. H. Babbage." *Parl. Pap., S. Austral.*, 1858, No. 154: 1 p.

BABBAGE, WARBURTON, GEHARTY, AND PARRY:

1858. "Northern Exploration. Report, etc., of Explorations into the Interior, by Messrs. . . ." *Parl. Pap., S. Austral.*, 1857, No. 25: 55 pp., 2 pls.

BABBAGE, WARBURTON, AND BURTT:

1858. "Northern Explorations. Reports from Messrs. Babbage and Warburton and Police Trooper Burtt on Exploration into the North and North-Western Interior of South Australia." *Parl. Pap., S. Austral.*, 1858, No. 151: 19 pp., 3 pls.

BAIN, D. B.:

1881. "Report on Country for Government Gums Railway. Report on Examination of Country for Extension of Government Gums Railway." *Parl. Pap., S. Austral.*, 1881, No. 165: 3 pp.

BARRON. See HARDY.

BROWN, H. Y. L.:

1883. "Report on North-East Country—Beltana, Waukaringa, Thackaringa, Mooleulooloo Hills, Yandama Creek, Milparinka, Innamincka, Pandie Pandie, Mulligan Springs, etc." With maps. *Parl. Pap., S. Austral.*, No. 146, 1883, fcp.

1884. "Geology of the Country passed over on Journey to the North-East." In *Ann. Rep. Gov. Geol., S. Austral.*, 1883, pp. 4-8, map, and 3 pls. (issued as *Parl. Pap., S. Austral.*, 1883, No. 35, and also issued as "Report of Government Geologist," *Parl. Pap., S. Austral.*, 1883, No. 146: 5 pp., with coloured geol. map and 3 coloured plates of sections, pp. 4-8, 4 pls.

1884. "Country passed over in the Vicinity of Mount Nor'-West, Farina, Mount Serle, etc." *Ann. Rep. Gov. Geol., S. Austral.*, 1883 (issued as *Parl. Pap., S. Austral.*, 1883, No. 35): pp. 8-10, 1 pl.

1884. "Geological Examination of the Colony. Report on . . . Beltana to Thackaringa, Blanchetown to Beltana, Mount Nor'-West, Farina, Mount Serle, etc. . . . Outline of General Geology, etc., etc. . . ." *Parl. Pap., S. Austral.*, No. 35 of 1884 fcp.

1884. "Government Geologists' Report *re* Visit to Far North. Report on the Country East and West of Farina." *Parl. Pap., S. Austral.*, 1884, No. 102: 4 pp.

1884. "Report on Country North-West and North-East of Farina." *Parl. Pap., S. Austral.*, 1884, No. 259.

1889. "The Mesozoic Plains of South Australia (south of lat. 26°)." *Rep. Austr. Assoc. Adv. Sci.*, vol. i. pp. 241-245.

1889. "Government Geologists' Report on a Journey from Adelaide to Hale River." *Parl. Pap., S. Austral.*, 1889, No. 24: 7 pp., map, and plate of section.

1889. "Geological Report of Journey from Warrina on the Transcontinental Railway to the Musgrave Ranges." *Parl. Pap., S. Austral.*, 1889, No. 45: 6 pp., 1 map, and 1 plate of sections.

1891. "Report on the Coal-bearing Area in the Neighbourhood of Leigh's Creek, South Australia, with Map and Sections explanatory of the Geological Formations, and showing the Position and Extent of Country occupied by the Coal-bearing Rocks." *Parl. Pap., S. Austral.*, 1891, No. 158: pp. 1-7, map, and 2 pls. of sections.

1892. "Report by Government Geologist on Country in the Neighbourhood of Lake Eyre." *Parl. Pap., S. Austral.*, 1892, No. 141: 5 pp., 1 map, 2 pls.

1892. "Memorandum in relation to the Further Geological Examination of Country in the Leigh's Creek and Hergott Districts, and the Alleged Discovery of Coal at Mulligan Springs." *Parl. Pap., S. Austral.*, 1892, No. 23, pp. 1-2.

1894. "Report on the Angepena Goldfield." *Ann. Rep. Gov. Geol., S. Austral.*, 1894, p. 5, map. *Parl. Pap., S. Austral.*, 1894, No. 25.

1894. "Report on the Discovery of Fossil Bones near Callabonna Station." *Ann. Rep. Gov. Geol., S. Austral.*, 1894: pp. 7-8, 2 pls. (Issued as *Parl. Pap., S. Austral.*, 1894, No. 25.)

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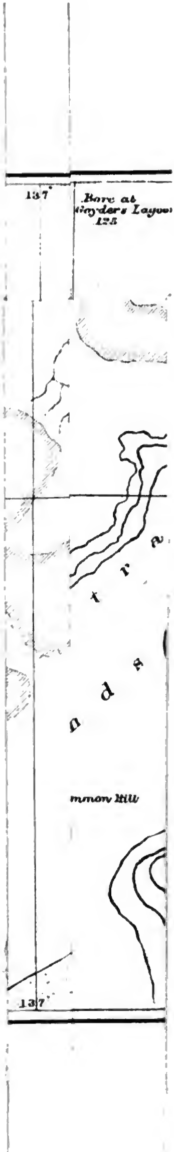

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